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Agency Summary

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL *YEAR* 1999 BUDGET ESTIMATES

NASA's VISION FOR THE FUTURE

NASA is an investment in America's future. As explorers, pioneers, and innovators, we boldly expand frontiers in air and space to inspire and serve America and to benefit the quality of life on Earth.

NASA's unique mission of exploration, discovery, and innovation has preserved the United States' role as both a leader in world aviation and as the preeminent spacefaring nation. It is NASA's mission to:

- Explore, use and enable the development of space for human enterprise:
- Advance scientific knowledge and understanding of the Earth, the Solar System, and the Universe and use the environment of space for research;
- Research, develop, verify and transfer advanced aeronautics, space and related technologies.

The outcomes of NASA's activities contribute significantly to the achievement of America's goals in four key areas:

- Economic growth and security - NASA conducts aeronautics and space research and develops technology in partnership with industry, academia, and other federal agencies to keep America capable and competitive.
- Preserving the Environment - NASA studies the Earth as a planet and as a system to understand global climate change, enabling the world to address environmental issues.
- Educational Excellence - NASA involves the educational community in our endeavors to inspire America's students, create learning opportunities, and enlighten inquisitive minds.
- Peaceful Exploration and Discovery - NASA explores the Universe to enrich human life by stimulating intellectual curiosity, opening new worlds of opportunity, and uniting nations of the world in this quest.

To fulfill NASA's mission of exploration, discovery and innovation, NASA sets the following overarching goals to take its science and aeronautics program proudly into the 21st century:

- NASA will be at the forefront of exploration and science. We will develop and transfer cutting-edge technologies in aeronautics and space. NASA will establish a permanent human presence in space.
- As NASA pursues its mission, NASA will enrich the Nation's society and economy. NASA will contribute to a better life for this and future generations.
- In the coming decades, it is our goal to undertake bold and noble challenges -- exciting future programs, which stir the imagination and fall within the grasp of the United States and its international partners' technical and financial grasp.

The President's national space policy, released in September 1996, underscores NASA's role as the lead Federal agency for civil space R&D. It features NASA's strengthening of its focus on cutting edge R&D and deemphasis on operational activities. The policy highlights priorities in human space flight (the International Space Station), science (Earth observation, continuous robotic presence on Mars surface, celestial sample returns and search for other Earth-like planets), and space technology (reuseable launch vehicles and smaller, cheaper space missions). It also underscores NASA's leveraging of industry through purchases of launch services, spacecraft, data products, communication services, and new technology: and continued close coordination with DoD and NOAA.

STRATEGY FOR ACHIEVING OUR GOALS

The framework for achieving these goals is embodied in the NASA Strategic Plan, which separates key NASA activities into four distinct Strategic Enterprises. They are:

- Earth Science (formerly Mission to Planet Earth):
- Aeronautics and Space Transportation Technology:
- Human Exploration and Development of Space: and,
- Space Science:

Each Enterprise, similar to the strategic business units employed by the private sector, has a unique set of strategic goals, objectives, and concerns, and a unique set of primary external customers. NASA also provides capabilities that are required for each Enterprise to achieve its goals and meet the needs of their customers. These agency-level activities serve multiple Enterprises and the strategies of these functions are driven primarily by the strategic plans of the Enterprises. The fundamental values of excellence, responsibility, teamwork, trust, and honor form the bedrock of all of NASA's activities.

NASA's Strategic Plan transcends its organizational structure. Each of the Strategic Enterprises seeks to respond to a unique customer community. Each of the Enterprises has its own set of technology needs which are closely linked to performing future planned missions while reducing the cost and technical risk. At the same time, there is considerable synergy between the Enterprise activities which strengthens each Enterprise. A broad description of the focus of each Strategic Enterprise follows:

Earth Science - The activities which comprise this Enterprise are dedicated to understanding the total Earth system and the effects of humans on the global environment. This pioneering program of studying global climate change is developing many of the capabilities which will be needed indefinitely, for long-term environment and climate monitoring and prediction. Governments around the world need information based on the strongest possible scientific understanding. The unique vantage point of space provides information about the Earth's land, atmosphere, ice, oceans, and biota as a global system, which is available in no other way. In concert with the global research community, the Earth Science Enterprise is developing the understanding needed to support the complex environmental policy decisions that lie ahead.

Aeronautics and Space Transportation Technology - NASA, and its predecessor, the National Advisory Committee for Aeronautics, have worked closely with U.S. industry, universities, and other Federal agencies to give the United States a preeminent position in

Aeronautics. The Aeronautics program will pioneer the identification, development, verification, transfer, application and commercialization of high-payoff aeronautics technologies. Future U.S. competitiveness in aeronautics and access to space, including the continued safety and productivity of the Nation's air transportation system, is dependent upon sustained NASA advances in aeronautics research and technology. Activities pursued as part of this Enterprise emphasize customer involvement, encompassing U.S. industry, the Department of Defense, and the Federal Aviation Administration. NASA is playing a leadership role as part of a Government-Industry partnership to develop breakthrough technology that will help the aviation community cut the fatal accident rate five fold within ten years and ten fold within twenty years. This new initiative, combined with the NASA investment in Air Traffic Management technology will enhance aviation safety and capacity called for by the White House Commission on Aviation Safety and Security chaired by Vice President Gore.

The Space Transportation Technology program will develop new technologies aimed at revitalizing access to space. The technologies targeted will reduce launch costs dramatically over the next decade, as well as increase the safety and reliability of current and future generation launch vehicles. Additionally, new plateaus of performance for in-space propulsion will be established, while reducing cost and weight. The Reuseable Launch Vehicle (RLV) program is pursuing technology development and concept definition activities in support of next-generation reuseable launch systems. The Advanced Space Transportation Program is developing key technologies to dramatically reduce space transportation costs across the mission spectrum, particularly advances with the potential of reducing launch costs beyond RLV goals. Future Space Launch Studies are being initiated to provide input to NASA and the Administration on an end-of-the-decade decision on whether to pursue an operational launch system to reduce NASA's launch costs as called for in the national Space Transportation Policy (NSTC-PD4). Programs in support of the effective transfer of NASA technology to the commercial sector are included in this Enterprise.

Human Exploration and the Development of Space - The Human Exploration and Development of Space Enterprise seeks to bring the frontiers of space fully within the sphere of human activities. HEDS conducts research and development to sustain a permanent human presence in space in low-earth orbit. HEDS will use the environment of space for research on biological, chemical and physical processes and facilitate the development of space for commercial enterprise. In pursuit of these goals, HEDS delivers knowledge and technologies that help to improve medical care and industrial processes on Earth while strengthening education and scientific literacy.

Space Science - The activities of the Space Science Enterprise seek answers to fundamental questions, such as understanding the origin and evolution of the universe and our solar system, if there are planets around other stars, whether the Earth is unique, and if life exists elsewhere, The quest for this information, and the answers themselves, maintains scientific leadership, excites and inspires our society, strengthens education and scientific literacy, develops and transfers technologies to promote U.S. competitiveness, fosters international cooperation to enhance programs and share their benefits, and sets the stage for future space ventures.

The Strategic Enterprises comprise an integrated national effort. Synergism of broad purposes, technology requirements, workforce skills, facilities, and many other dimensions was the basis for amalgamating these activities in NASA in the National Aeronautics and Space Act in 1958, and the benefits remain strong today.

PLANS AND ACCOMPLISHMENTS

The NASA budget request for FY 1999 continues the President's commitment to invest in the future. This budget request recognizes the enormous potential for investments in the civil space and aeronautics program to benefit this country. The President's FY 1999 budget proposes the creation of a Research fund for America, which dedicates resources for an aggressive and sustained investment in Federal research. NASA's programs in Space Science, Earth Science, Advanced Space Transportation, and Aeronautics are included in the Fund.

The NASA Space Science program has achieved impressive successes this past year – the landing of the Mars Pathfinder spacecraft on the surface of Mars and exploration of the surrounding terrain by the Sojourner rover; new discoveries by the Hubble Space Telescope of over 1,000 bright, young star clusters resulting from the collision of two galaxies; the launch of the Cassini spacecraft to Saturn, and Galileo's detailed examination of Jupiter and its moons. To capitalize on these enormous successes during the past year, the NASA budget request for FY 1999 highlights the Space Science program. Additional funding supports: an augmentation to the Mars Surveyor Program to enhance the Mars 2001 lander; the initiation of a series of Solar-Terrestrial Probes to track solar phenomena and their impact on the Earth: and the initiation of mission development for the Gamma-ray Large Area Space Telescope (GLAST) to understand the end states of stars' lives and to seek out the most extreme environments in the universe. The budget also continues NASA's commitment to the search for the origins of life. In response to evidence of possible subsurface oceans discovered by the Galileo mission on Jupiter's moon Europa, NASA will begin planning for a Europa mission to launch in 2003 to directly observe potential subsurface oceans on Europa. The Space Science program seeks to answer fundamental questions concerning: the galaxy and the universe; the connection between the Sun, Earth and heliosphere; the origin and evolution of planetary systems; and the origin and distribution of life in the universe. NASA's Space Science program is responsive to the President's national space policy and is a vital component of the Administration's investment strategy in science and technology.

The President's Space Policy, issued in September 1996, outlined a strong and stable program in space that will ensure America's role as the world's space leader. The Space Policy reaffirmed the United States' commitment to the International Space Station, to the next generation of launch vehicle programs, to an aggressive space science program, and to the continuing commitment to a long-term program of environmental monitoring from space. The President's strategy for investing in science and technology, encompassing goals which emphasize world leadership in science, mathematics and engineering, economic growth, improved environmental quality, and harnessing information technology continues as the framework for development of federal science and technology policy. The President's budget request for NASA for FY 1999 fully supports these goals.

The emphasis on cheaper, more capable science missions is continued in the FY 1999 budget request. These programs experiment with new innovative management and procurement practices, promote smaller affordable missions and enforce strict adherence to performance criteria and cost caps.

- The Discovery program reflects NASA's commitment to ensuring a continuous stream of new planetary science data and more frequent access to space. The third Discovery mission, Lunar Prospector, was successfully launched in January 1998.
- The Mars Surveyor program is a series of small missions designed to resume the detailed exploration of Mars. The second series of Mars Surveyor spacecraft will be launched during the next launch opportunity in December 1998 and January 1999.
- The Office of Space Science restructured its technology program to ensure technology capabilities for the future. First, a *core program* of technologies for multiple space science missions, as well as cross-cutting spacecraft and robotics technologies for multiple NASA Enterprises. Second, several *focused programs* dedicated to specific high priority technology mission areas. Third, a *flight validation program* called the New Millennium program completes the technology development process by validating technologies in space.
- Technologies for the first two Space Science New Millennium missions have been selected and development has begun, with flight of the Deep Space-1, first mission, scheduled for July 1998, and the Deep Space-2, the second, scheduled in January 1999.
- The Earth System Science Pathfinder (ESSP) is a science-driven program intended to identify and develop small satellite missions to accomplish scientific objectives in response to national and international research priorities not addressed by current programs. The first two ESSP missions selected in 1997 are the Vegetation Canopy Lidar (VCL) and the Gravity Recovery and Climate Experiment (GRACE).

In order to achieve significant savings in the cost of space missions, the cost of going to orbit must be reduced by orders of magnitude. The Reusable Launch Vehicle program is addressing, in partnership with the private sector, the new and innovative technologies that are needed to meet the challenges and lower the costs of future space missions. Phase II of the **X-33** program, encompassing both ground and flight tests, is under way, and **is** expected to lead to a decision by the government and our industry partners whether full-scale development of an RLV should be pursued. This program utilizes an innovative management approach, based on industry-led cooperative agreements. The government is acting as partners and subcontractors, reporting costs and workforce to the industry team leader as would any other subcontractor. This approach allows a much leaner management structure, lower program overhead costs and increased management efficiency.

The 1994 National Space Transportation Policy (NSTC-PD4) calls for an end-of-the-decade decision on the development of an operational launch system to reduce NASA's launch costs. To support this decision, industry-led Future Space Launch trade studies are being undertaken to provide input to NASA and the Administration on an appropriate approach. Separate efforts being undertaken, such as the Crew Rescue Vehicle (CRV) for Station, Future-X demonstration strategy, and possible business plans for **X-33** Phase III would contribute to these studies. Placeholder funds are set aside in the outyears to pursue existing, planned or new vehicles in response to the Administration's end-of-the-decade decision.

NASA's ability to inspire and expand the horizons of present and future generations rests on the success of these efforts to maintain this nation's leadership in space within the reality of the fiscal constraints facing the federal budget. In order to ensure the stability to manage and execute programs within budget and schedule, NASA is seeking multi-year appropriations for the International Space Station

NASA has been at the forefront of the Administration's efforts to reshape the federal government, to make it smaller, cut costs, and be more responsive to the ultimate customer, the taxpayer. NASA's civil service workforce was reduced an additional 618 full time equivalents over the FY 1997 baseline of 20,501. Total civil service employment for NASA at the end of FY 1997 was 19,883 full time equivalents.

NASA continues to be a leader in responding to the challenge of reducing the federal deficit and the goals of the National Performance Review. Over the past several years, NASA has undergone a thorough scrutiny of its mission, organization and activities. A strengthened program management system has been implemented and the Program Management Council regularly reviews the technical, schedule and financial status of NASA's major activities. A disciplined process has been established for the early identification of problems, and guidelines for addressing a solution. This process has resulted in senior management attention focused on program performance. A new Strategic Management process has been put in place to provide a continuous process for NASA to make critical decisions about its long-term goals, near-term activities, and institutional capabilities that are in alignment with customer requirements. A fundamental goal of NASA's Strategic Management process is to ensure that the Agency provides its customers with excellent products and services in the most cost-effective and timely manner,

The NASA budget request for FY 1999 is reflected in four appropriations:

Human Space Flight - providing funding for the Space Station and Space Shuttle programs, including development of research facilities for the International Space Station and flight support for cooperative programs with Russia;

Science, Aeronautics and Technology - providing funding for NASA's research and development activities, including all science activities, global monitoring, aeronautics, technology investments, education programs, mission communication services and direct program support;

Mission Support - providing funding for NASA's civil service workforce, space communication services, safety and quality assurance activities, and facilities construction activities to preserve NASA's core infrastructure:

Inspector General - providing funding for the workforce and support required to perform audits and evaluations of NASA's programs and operations.

HUMAN SPACE FLIGHT

This appropriation encompasses all human space flight activities, including development of the Space Station and the safe and efficient operation of the Space Shuttle. The International Space Station is the culmination of the redesign work begun in FY 1993 to reduce program costs while still providing significant research capabilities. Space Station partners include NASA, the Russian Space Agency (RSA), European Space Agency (ESA), the Canadian Space Agency (CSA), and the National Space Development Agency of Japan (NASDA). The partnerships significantly enhance the capabilities of the International Space Station, and ensure compatible interfacing elements. The program is led by a single contractor, Boeing North American, which has total development and integration responsibilities. A streamlined program office at the Johnson Space Center has primary management responsibility for the program, including responsibility for bringing the systems and elements into integrated launch packages.

The Administration continues to be strongly committed to development of the International Space Station, and the preservation of the partnerships between the United States, Russia, Europe, Japan and Canada. Station assembly begins in mid- 1998 and will continue through the end of 2003. The proposed budget provides multi-year funding for development and operation of the Station. Sufficient additional funding is being requested for the International Space Station to maintain the program on schedule and minimize the total cost.

During the past year, the Space Station program has focused on the continued qualification testing and manufacture of flight hardware as the program readies for first element launch in June 1998 and subsequent launches throughout 1999. In 1997, node and laboratory module fabrication were completed, and at the end of the year completed flight hardware totaled approximately 220,000 pounds. The node (Node 1) and pressurized mating adapter (PMA 1) were delivered to the launch site, and qualification testing of flight hardware components continued. Activities are well under way to support crew training, payload processing, and hardware element processing requirements. The program has completed stage integration reviews for the first element launch through the seventh flight. The International Space Station partners continued development of flight hardware.

During FY 1998, the major program focus will be the launches of the U.S-owned/Russian-launched Functional Cargo Block (FGB), Node 1, and PMA 1 and PMA 2. Major hardware element deliveries to the launch site will include the PMA 2, Z1 truss, integrated electronics assembly, mini-pressurized logistics module, and the U.S. laboratory. Stage integration reviews will be performed for the flights through the twelfth launch. The Mission Control Center (MCC) at the Johnson Space Center (JSC) is the prime site for the planning and execution of integrated system operations of the Space Station, with exclusive command and control authority. The MCC at JSC and the MCC at Kalingrad form the unified command and control center for the Space Station.

Funding for all elements of the Space Station program is included in the Human Space Flight appropriation. This allows maximum flexibility in providing a balanced program, especially as program activities intensify in support of First Element Launch and subsequent launches. Program elements included in the International Space Station budget are: Space Station Development, Operations, and the Research Program, including research facilities, and the flight support component of the Russian cooperation program to Mir. Program reserves are being closely monitored to maintain as high a level as possible to address technical and contract performance issues that are occurring during this peak period of Space Station engineering and development.

NASA is taking no action at this time which would result in a slip in program schedule as a result of the $200 million shortfall identified in FY 1998. In recognition of the need to address this shortfall, NASA plans to reallocate $27 million within the Human Space Flight appropriation and seek transfer authority for the remaining $173 million from the Science, Aeronautics and Technology and Mission Support accounts. The Administration will be requesting the transfer authority as part of its FY 1998 Budget Supplemental. Upon enactment of the transfer authority, NASA plans to transfer $73 million immediately , with the remaining $100 million to be transferred as warranted. The FY 1998 budget estimates in this request assume application of the full $173 million requirement, as well as the reallocation of $27 million from within Human Space Flight funds.

The highest priority of the Shuttle program remains the safe launch, operation and return of the orbiter and crew. Funding is included to continue modifications that will significantly improve the Space Shuttle's overall safety, including modifications to the Main Engine and the Orbiter, as well as continuation of the program of upgrades to increase reliability and maintainability. In addition, funding for investments to improve Shuttle performance, such as the Super Lightweight External Tank, is included in order to satisfy space station requirements. Transition to a consolidation of Space Shuttle operations contracts into a single prime contractual arrangement was accomplished in October 1996. Transition activities will continue over the next 2 years. It is expected that this consolidation will achieve the challenge of finding additional cost savings in the outyears. These savings have been incorporated into **NASA's** budget planning.

During 1996-97, valuable experience was gained in docking procedures during six Space Shuttle flights to the Russian Space Station Mir. U.S. astronauts maintained a continuing presence on the Mir, highlighted by the record-setting stay of 181 days by astronaut Shannon Lucid, and the challenging but successful stay of astronaut Michael Foale . This experience is allowing **NASA** to gain valuable experience in the long term effects of weightlessness, as well as allowing the United States and Russia to work closely together in as Space Station partners. In 1998, an American astronaut will be continuously on board the Mir Space Station, performing scientific experiments. Currently, nine joint U.S. visits to the Mir are planned, which will provide approximately 24 months of on-orbit time to test science hardware planned for the Space Station. The last two Mir flights are planned for FY 1998.

In FY 1997, eight Space Shuttle missions were completed, including three missions to the Mir Space Station. Six missions are planned for FY 1998, including the last two missions to the Mir Space Station and, the last Spacelab flight (Neurolab),and the initial assembly flight for the International Space Station (ISS). Eight missions are planned for FY 1998; six of these flight are ISS assembly flights.

SCIENCE, AERONAUTICS AND TECHNOLOGY

Space Science

The Space Science program is designed to expand our scientific understanding of the Sun, solar system, and universe beyond Earth. It seeks answers to fundamental questions, such as understanding the origin and evolution of the universe and our solar system: if there are planets around other stars: whether the Earth is unique; and, if life exists elsewhere. In 1997, highlights included the July 4 landing of the Pathfinder spacecraft on Mars, the first Mars landing since the Viking missions in 1976 and the first ever to use air bags to cushion a surface impact. Shortly after Pathfinder's landing, the Sojourner rover began its own exploration of nearby rocks and other features. The images from both craft were posted to the Internet, where more than 500 million "hits" were recorded by the end of July. The international Cassini mission left Earth bound for Saturn on Oct. 15. 1997. With the European Space Agency's Huygens probe and a high-gain antenna provided by the Italian Space Agency, Cassini will arrive at Saturn July 1, 2004. **Also,** astronauts flawlessly performed major maintenance and upgrades to the orbiting Hubble Space Telescope, replacing older hardware with two dramatically improved instruments that are helping astronomers probe the universe in greater detail than ever before. This year, Hubble uncovered over 1,000 bright, young star clusters bursting to life in a brief, intense, brilliant "fireworks show" at the heart of a nearby pair of colliding galaxies. The Hubble image of the galactic collision was printed on the front pages of newspapers around the world as well as on the cover of Newsweek magazine. Images captured during Galileo's closest flyby of Europa on Feb. 20 showed features of the Jovian moon, lending credence to the possibility of hidden, subsurface oceans and generating new questions about the possibility of life on Europa. Scientists using the joint European Space Agency/NASA Solar and Heliospheric Observatory (SOHO) spacecraft have discovered "jet streams" or "rivers" of hot, electrically charged plasma flowing beneath the surface of the Sun. These new findings will help scientists understand the famous 11-year sunspot cycle and associated increases in solar activity that can disrupt the Earth's power and communications systems.

The Space Science program continues **a** robust program of flight development activities. To capitalize on these enormous successes during the past year, the NASA budget request for FY 1999 once again highlights the Origins program. The program focuses on fundamental questions regarding the creation of the universe and planetary systems, and the possibility of life beyond Earth. The strategy for addressing these questions involves returning surface samples from Mars and deploying powerful telescopes, including a space-based interferometer (SIM), a follow-on to the Hubble Space Telescope (Next-Generation Space Telescope (NGST)), and ultimately, a large interferometer system, the Terrestrial Planet Finder (TPF), to detect Earth-like planets elsewhere in our galaxy. NASA's Origins program is responsive to the President's national space policy and is a vital component of the Administration's investment strategy in science and technology.

In addition to Origins, the Space Science Enterprise features a balanced program aimed at achieving the Enterprise mission: to solve mysteries of the universe, explore the solar system, discover planets around other stars, search for life beyond Earth; from origins to destiny, chart the evolution of the universe and understand its galaxies, stars, planets, and life. While Origins is highlighted among the four major Space Science themes, the FY 1999 budget funds an aggressive program in each of the three other areas. The Solar System Exploration theme will send robotic spacecraft to investigate the planets, moons and comets orbiting our Sun. Funding in this area now supports a Europa orbiter mission with a launch date in 2003, as well as mission definition and technology development for **a** series of missions to outer planets and comets. The Sun-Earth Connections (SEC) theme is focused on observing the Sun itself as a typical star and as the controlling agent of the space environment of the Solar System, especially the Earth. Future SEC missions under study and technology development in this budget include Solar-B and Solar Terrestrial Relations Observatory (STEREO). The Structure and Evolution of the Universe theme studies the large-scale structure of the universe, the Milky Way and objects of extreme physical conditions, in order to explain the cycles of matter and energy in the evolving universe, to examine the ultimate limits of gravity and energy and to forecast our cosmic destiny. Future missions funded for concept analysis, definition and technology development in this budget include Gamma Ray Large Area Space Telescope (GLAST), the Far lnfrared Space Telescope (FIRST) and the Constellation X-ray Mission.

Development activities will continue in 1998-1999 on the Advanced X-ray Astrophysics Facility (AXAF) in support of the revised launch date of early FY 1999. Development activities continue on the Relativity (Gravity Probe-B) mission, which remains on schedule for launch in 2000. The Space lnfrared Telescope Facility (SIRTF) initiates development in April 1998, with launch planned for December 2001. Development activities on the Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED) mission began in 1997, with launch planned in 2000. Development activities on the Stratospheric Observatory for Infrared Astronomy (SOFIA) continue to receive support. The Second Hubble Space Telescope (HST) servicing mission in February 1997 provided two new science instruments in addition to other servicing, and the upgraded telescope is providing new insights into our universe by investigating objects in the near-infrared portion of the electromagnetic spectrum. Funding for HST continues to support operations, as well as preparation for the third servicing mission in 1999. Galileo's highly successful tour of Jupiter and its moons has been extended through 1999, with a focus on the moons Europa and Io.

In Explorer missions, the Advanced Composition Explorer (ACE) was launched in August 1997 and development activities continue on the Far Ultraviolet Spectroscopy Explorer (FUSE) for a launch in 1998. Development is also under way for the Microwave Anisotropy Probe (MAP) and Imager for Magnetosphere-to-Aurora Global Exploration (IMAGE) Medium-Class Explorer (MIDEX) missions. Three new Small (SMEX) missions were selected in 1997: the High Energy Spectroscopic Imager (HESSI) is to launch in 2000; the Galaxy Evolution Explorer (GALEX) will launch in 2001; the Two Wide-Angle Neutral-Atom Spectrometers (TWINS) has been selected as a mission of opportunity, to be launched in 2001 or 2003 aboard a currently undesignated U.S. Government mission. These missions emphasize reduced mission costs and accelerated launch schedules.

The Mars Global Surveyor entered Mars orbit in September 1997, and funds are requested for the development of future Mars missions in 1998 and beyond. The third Discovery-class mission, Lunar Prospector, was launched in January 1998, the fourth, the Stardust mission, is to be launched in 1999. Two new Discovery missions were selected in 1997: the Comet Nucleus Tour (CONTOUR) to be launched in 2002; and Genesis, a solar wind sample return mission, to be launched in 2001. A mission to Europa is planned for launch in 2003. The New Millennium program is under way to provide flight demonstrations of critical new technologies which will greatly reduce the mass and cost of future science instruments and spacecraft subsystems, while maintaining or improving mission capabilities. Development activities continue on the Deep Space-1 and Deep Space-2 missions, scheduled for launch in July 1998 and January 1999, respectively.

The Space Science budget contains the funding for core technology development in support of all NASA enterprises, including Space Science. The Space Science budget also includes a separate aggressive technology development effort to enable new missions to the outer planets, and to search for Earth-like planets around nearby stars. New technologies are also being pursued to enhance our capability to explore Mars robotically, and perhaps to confirm the past or current presence of life on that planet.

Life and Microgravity Sciences and Applications

NASA's Office of Life and Microgravity Sciences and Applications (OLMSA) seeks to advance scientific knowledge, to enable the development of space for human enterprise, and to transfer the knowledge and technologies developed as broadly as possible. We seek to enable and exploit the possibilities of human space flight to improve the quality of life for people on Earth. OLMSA implements its programs through ground-based research, research on uncrewed free-flying vehicles, Space Shuttle Missions, research on the Russian Mir Space Station, and , in the future, on the ISS.

In FY 1997, NASA's OLMSA conducted significant national and international research during long duration missions aboard the Mir Space Station. OLMSA provided world class medical operations for the extended duration missions of John Blaha, Jerry Linenger and Mike Foale during their stays aboard the Mir Space Station. Space Shuttle missions included the Microgravity Space Laboratory (MSL-1) mission, launch of the Wake Shield Facility, and other small and middeck payloads. MSL included investigations in the disciplines of biotechnology, combustion science, fluid physics and materials science, and consistently exceeded researcher objectives. The mission yielded the first measurements of specific heat and thermal expansion of glass-forming metallic alloys and resulted in the highest temperature and largest undercooling ever achieved in a space experiment. More than 200 combustion experiments runs (fires) were conducted on MSL-1, resulting in the discovery of a new mechanism of flame extinction caused by radiation of heat from soot. In ground-based research, OLMSA's Advanced Human Support Technology program completed a 336-day closed-chamber wheat and potato shared-atmosphere evaluation at KSC as well as a 60-day, closed-chamber ISS life support system test with four humans at JSC.

In FY 1998 OLMSA will conduct Neurolab, a Spacelab mission conducted cooperatively with the National Institutes of Health dedicated to life sciences research. The Neurolab mission will conduct basic research in sensory-motor coordination, vestibular function, spatial orientation, developmental biology, nervous system plasticity, autonomic nervous system control of the cardiovascular system, sleep and circadian rhythms, and human behavior. The fourth US microgravity payload will fly in the Space Shuttle payload bay to conduct materials science and fundamental physics research. Preparations for the first missions to ISS will commence with the selection of the principal investigators and crew training in 1998. In FY 1999, the US lab of the ISS will be launched. Final preparations will be completed in FY 1998 for the flight of STS-95, a dedicated research mission focusing on commercial and biotechnology research scheduled for early FY 1999.

Earth Science

The Earth Science program seeks to improve the scientific understanding of the Earth system, including the mechanisms that drive the climate and ecology of Earth, and how human activity is affecting the environment. NASA's base program combines ground-based measurements , laboratory studies, data analysis and model development with a progressive series of satellite missions to study cloud climatology, Earth radiation budget, ozone levels, atmospheric chemistry, changes in land cover and ocean circulation. This is just a first step. The capability to model and predict the consequences of global change is the ultimate objective.

The ongoing Earth Science program is making critical near-term contributions to understanding the Earth as an integrated system as well as environmental issues, such as global warming and ozone depletion. Data from satellites and instruments in orbit, such as Total Ozone Mapping Spectrometer (TOMS), the Upper Atmospheric Research Satellite (UARS), Qcean Topography Experiment (TOPEX)/Poseidon, and the Earth Radiation Budget Experiment (ERBE) are being used in multidisciplinary studies focused on understanding various aspects of the global environment.

The Earth Observing System (EOS) is a key element in the Administration's U.S. Global Change Research Program, and NASA's major contribution to this effort. The EOS is a series of spacecraft designed to provide long-term data sets for use in modeling and understanding global processes. The Earth Probes provide data in specialized areas, such as tropical rainfall, ocean wind speed and direction, and global ozone concentrations. The EOS Data Information System (EOSDIS) **will** provide the processing, storage, and distribution of the EOS science data and resulting scientific products. Funding for the continued development of the Landsat-7 spacecraft, instruments and ground system is included. Landsat-7 is scheduled to launch in 1998. After launch and check out, the National Oceanic and Atmospheric Administration (NOAA) will be responsible for Landsat-7 operations.

Funding requested for FY 1998 and FY 1999 supports the continued development of the EOS program, including a robust science program. The first EOS satellites, Landsat-7 and EOS AM-1, will be launched in 1998. Preceding launch of the EOS satellites, a number of individual satellite and Shuttle based missions are helping to reveal basic processes. NASA has begun work on a new start for the Quick Scatterometer (QuikSCAT) mission, which will fill in the ocean-wind vector data gap created by the loss of the NASA Scatterometer (NSCAT) on the Japanese Advanced Earth Observing Satellite (ADEOS) spacecraft. Complementing EOS will be a series of small, rapid development Earth System Science Pathfinder missions, and an aggressive technology development program to provide for the infusion of innovative new technologies into the second and third series of EOS measurements. Funding also supports LightSAR as free-flying, Earth-observing, lightweight, synthetic aperture radar (SAR) mission.

Aeronautics and Space Transportation Technology

The Aeronautics and Space Transportation Technology program provides high payoff, critical technologies with effective transfer of design tools and technology products to industry and government.

The Aeronautics program provides a broad foundation of advanced technology to strengthen the United States' leadership in aviation, an industry which plays a vital role in the economic strength, transportation infrastructure and national defense of the United States. The NASA Aeronautics program provides the nation with leadership in high payoff critical technologies which are transferred to industry, the Department of Defense, and the Federal Aviation Administration for application to safe, superior and environmentally compatible U.S. civil and military aircraft, and for a safe and efficient National Aviation System. NASA's unique research capabilities contribute to the strengthening of America's aviation industry in many ways, and the FY 1998 program continues important investments required to pursue the high leverage technologies required to support both the subsonic and high-speed civil transport economic viability.

The Advanced Subsonic Transport (AST) program continues to make substantial progress in the development of high-risk, high-payoff technologies for a new generation of environmentally compatible, economic subsonic aircraft and a safe, highly productive global air transportation system. NASA, in partnership with the FAA, DoD and the aviation industry, is investing a half billion dollars over the next five years to develop breakthrough technology that will help the aviation community cut the fatal accident rate five fold within ten years and ten fold within twenty years. The AST program has been refocused to emphasize technologies which will significantly enhance the safety of the aviation system, improve the environment through noise and emissions reductions, and increase the capacity for a highly productive global air transportation system. Funding is included to continue development of high payoff technologies enabling a safe, highly productive global air transportation system with reduced environmental impact.. This initiative is in response to recommendations from the White House Commission on Aviation Safety and Security, announced by the President on February 12, 1997.

The HSR program continues to develop technologies to establish the viability of an economical and environmentally sound High Speed Civil Transport (HSCT), a vehicle that—if built by U.S. industry—could provide U.S. leadership in the long-range commercial air travel markets of the next century, offering returns of billions of dollars in sales and numerous high-quality jobs for the U.S. workers. Due to the successful results in the existing HSR program, an extension is proposed called Phase IIA, that will begin in FY 1999. HSR Phase IIA will focus on answering the remaining technology questions on whether U.S. industry will be able to build a viable, economical and environmentally sound HSCT. The work of Phase IIA will be essential to enabling industry to make a sound business decision on whether a market exists for an American HSCT.

NASA is an active participant in the High Performance Computing and Communications (HPCC) program, and has pioneered the application of design and simulation software on parallel machines and developed the most widely accepted performance evaluation/tuning software for applications on parallel machines. In FY 1999, NASA will continue to support the Administration's Next Generation Internet (NGI) initiative, to increase the quality, security and certainty of Internet transmissions and to increase network capacity 1,000 times the capacity of the baseline. Research activities conducted within the Research and Technology Base, providing the vital foundation of expertise and facilities that meets a wide range of aeronautical technology challenges for the nation. The program provides a high-technology, diverse-discipline environment that enables the development of new, even revolutionary, aerospace concepts and methodologies for applications in industry. These goals are driven by the need to reduce product costs and capture increased global market share. Work within the R&T Base lays the foundation for future new focused technology programs to address specific, high value national needs and opportunities the long term goals of the Aeronautics and Space Transportation Technology Enterprise. This work constitutes a national resource of expertise and facilities that responds quickly to critical issues in safety, security, and the environment. These same technological resources contribute to the overall U.S. defense and non-defense product design and development capabilities.

The Space Transportation Technology program leads NASA's efforts to develop advanced space technologies critical to the economic, scientific, and technological competitiveness of the U.S. The program is developing new technologies aimed at revitalizing access to space. The technologies targeted will reduce launch costs dramatically over the next decade, and increase the safety and reliability of current and future generation launch systems. In 1997, the Reusable Launch Vehicle (RLV) program continued to pursue technology development, design and business planning activities in support of next-generation reusable systems, on the **X-33** and **X-34** flight demonstrators. The **X-33** and **X-34** have completed their critical design reviews and initiated fabrication of flight hardware. Funding for the RLV program in 1998 and 1999 is included to continue **X-33** and **X-34** technology development, hardware fabrication and test, in preparation for the flight of the technology demonstrators, both of which will fly in 1999. The Advanced Space Transportation Program (ASTP) is developing key technologies to dramatically reduce space transportation costs across the mission spectrum. ASTP will focus on technological advances with the potential of reducing launch costs beyond RLV goals, as well as on developing technology required to support NASA strategic needs that are not currently addressed by RLV. Future Space Launch Studies are being initiated to provide input to NASA and the Administration on an end-of-the-decade decision on whether to pursue an operational launch system to reduce NASA's launch costs.

In order to ensure national economic strength enhancements derived from NASA technology, NASA will pursue a commercial technology mission concurrent to its aerospace mission. The commercial technology mission requires that each NASA program be carried out in a way that proactively involves the private sector from the onset, through a new way of doing business, to ensure that the technology developed will have maximum commercial potential. This new mission requires NASA to impart., to the maximum extent possible, the benefits of its technological assets to the national economy and to use, to the maximum extent possible, the strengths of the U.S. industrial base. In accomplishing this mission, NASA supports the development and transfer of technology which leads to new commercial products and services.

The Commercial Technology Program achieves this new mission through one of NASA's crosscutting functions -- to provide aerospace products and capabilities to NASA customers. The Commercial Technology Program transfers NASA technology and technical expertise to commercial customers more effectively and efficiently while extending the technology, research and science benefits broadly to the public and commercial sectors. Some of the objectives are to proactively transfer technology through commercialization partnerships, and to integrate innovative approaches to strengthen U.S. competitiveness. Funding for the Commercial Technology Program continues to support development of commercial partnerships with industry. In FY 1998 and FY 1999, emphasis will be on increasing commercial partnerships with industry and continued refinement of a technology and partnership database.

Academic Programs

Science and mathematics achievement is an integral element of the National Education Goals, and NASA's efforts in the education arena strongly support making U.S. students first in the world in science and mathematics achievement by the year 2000. NASA's programs at the pre-college, college and graduate levels use NASA's unique mission and results to capture and channel student interest in science, mathematics and technology, as well as enhance teacher and faculty knowledge and skills related to these subjects. At the undergraduate and graduate level, programs are geared to providing opportunities for students and faculty to participate in NASA-sponsored research activities at NASA field centers.

NASA has made a commitment to playing a leadership role in strengthening the capabilities of minority universities and to increasing opportunities for students at Historically Black Colleges and Universities and Other Minority Universities, primarily Hispanic-serving institutions and Tribal Colleges, to participate in and benefit from NASA's research and education programs. The FY 1998 budget request for the Minority University Research program continues this commitment through funding for initiatives which are under way.

Mission Communication Services

Support which is most directly related to NASA's science and aeronautics programs, including ground network support, mission planning for robotics spacecraft programs, suborbital mission support, support to aeronautics test programs, and technology development activities to improve the state of space communications technology, is included in the Science, Aeronautics and Technology appropriation. Efforts are ongoing to consolidate and streamline major support contract services in order to optimize space operations. Transition to a Consolidated Space Operations Contract (CSOC) is planned in FY 1998. The CSOC acquisition process is being implemented in two phases. Two 8-month fixed-price study contracts were awarded to Boeing North American and Lockheed Martin, Incorporated on May **16,** 1997 to develop an integrated Operations Architecture (IOA). The IOA and a proposal to implement the IOA to provide space operations services during a five-year basic contract, with a five-year option. The 90-day phase-in period is planned to start on July 1, 1998. This full and open competition is expected to produce efficiencies and economies over the life of the contract which benefits all NASA programs. Specifically, the integrated architecture is expected to maximize space operations resources by reducing systems overlap and duplication.

MISSION SUPPORT

Safety, Mission Assurance, Engineering, and Advanced Concepts

NASA is committed to safety and mission success in all of its programs. The Office of Safety and Mission Assurance (OSMA) is responsible for the development and implementation of safety and mission assurance (SMA) practices, including risk management, into all NASA activities. The funding requested will continue a wide range of activities under way through which SMA practices are integrated into the earliest phases of development for space and aeronautics programs. The Office of the Chief Engineer provides a focus for NASA's engineering discipline, oversees applications, and improves NASA's practices and capabilities through targeted initiatives in the Engineering programmatic area. The Office of the Chief Technologist also evaluates advanced aerospace concepts for feasibility and benefits.

Space Communications Services

Funding for the operation, sustainment, and replenishment of NASA's Space Network is in NASA's Mission Support appropriation. This program supports the operation of the Tracking and Data Relay Satellite (TDRS) System, the ground terminals at White Sands, New Mexico, and the NASA Control Center at the Goddard Space Flight Center. Funds for services provided to non-science users of the TDRSS are included under this program. The NASA Integrated Services Network are also funded by this appropriation. Efforts are ongoing to consolidate and streamline major support contract services in order to optimize space operations. Transition to a Consolidated Space Operations Contract (CSOC) is planned in FY 1998. as discussed above.

Research and Program Management

The NASA workforce is the foundation underpinning the successful achievement of NASA's goals. Funding for the salaries, travel support and other personnel expenses for the entire NASA workforce is included. Funding for support activities to the NASA workforce and physical plant is also included in Research and Program Management.

NASA's civil service workforce in 1999 continues the downsizing process initiated several years ago. Their expertise is essential to the timely, cost-effective and crucial research and development that NASA programs feature. NASA's budget request for FY 1999 continues the management policy of using buyouts to achieve reductions in planned levels of civil service staffing and support. Current planning supports a civil service workforce of around 17,800 by FY 2000. Training dollars will re requested at levels sufficient to keep the workforce technically prepared to meet the challenges of NASA's diverse and highly technical programs.

Construction of Facilities

Funding is included for discrete projects to repair and modernize the basic infrastructure and institutional facilities, the minor repair, rehabilitation and modification of existing facilities, minor new construction projects, environmental compliance and restoration activities, the design of facilities projects, and the advanced planning related to future facilities needs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL *YEAR* 1999 ESTIMATES
(IN MILLIONS OF REAL *YEAR* DOLLARS)

	BUDGET PLAN		
	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
HUMAN SPACE FLIGHT	**5674.8**	**5679.5**	**5511.0**
SPACE STATION	2148.6	2501.3	2270.0
US/RUSSIAN COOPERATION	300.0	50.00	--
SPACE SHUTTLE	2960.9	2922.8	3059.0
PAYLOAD AND UTILIZATION OPERATIONS	265.3	205.4	182.0
SCIENCE, AERONAUTICS AND TECHNOLOGY	**5453.1**	**5552.0**	**5457.4**
SPACE SCIENCE	1969.3	1983.8	2058.4
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	243.7	214.2	242.0
EARTH SCIENCE	1,361.6	1,367.3	1,372.0
AERONAUTICS AND SPACE TRANSPORTATION TECHNOLOGY	1339.5	1470.9	1,305.0
MISSION COMMUNICATION SERVICES	418.6	395.8	380.0
ACADEMIC PROGRAMS	120.4	120.0	100.0
[ENTERPRISE FUNDING IN SUPPORT OF MINORITY PROGRAMS]	[13.31	[20.8]	[28.8]
MISSION SUPPORT	**2564.0**	**2388.2**	**2476.6**
SAFETY, MISSION ASSURANCE, ENGINEERING, AND ADVANCED CONCEPTS	38.8	37.8	35.6
SPACE COMMUNICATION SERVICES	291.4	194.2	177.0
RESEARCH AND PROGRAM MANAGEMENT	2078.5	2033.8	2099.0
CONSTRUCTION OF FACILITIES	155.3	122.4	165.0
INSPECTOR GENERAL	**16.8**	**18.3**	**20.0**
TOTAL BUDGET AUTHORITY	**13708.7**	**13638.0**	**13465.0**
TOTAL OUTLAYS	**14357.0**	**13729.0**	**13504.0**

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1999 ESTIMATES
SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS
(IN MILLIONS OF REAL YEAR DOLLARS)

	TOTAL	Human Space Flight	Science, Aero & Technology	Mission Support	Inspector General
FISCAL YEAR 1997					
VA-HUD INDEPENDENT AGENCIES APPROPRIATIONS ACT, FY 1997 (P.L. 104-204)	**13,704.2**	**5,362.9**	**5,762.1**	**2,562.2**	**17.0**
OMNIBUS CONSOLIDATED APPROPRIATIONS ACT (P.L. 104-208)	**5.0**		5.0		
VA-HUD INDEPENDENT AGENCIES APPROPRIATIONS ACT, FY 1997 (P.L. 104-204) APPROPRIATIONS TRANSFER AUTHORITY	**0.0**	177.0	-177.0		
LAPSE OF FY 1997 UNOBLIGATED FUNDS	**-0.5**			-0.2	-0.2
TOTAL FY 1997 BUDGET PLAN	**13,708.7**	**5,539.9**	**5,590.1**	**2,562.0**	**16.8**
FISCAL YEAR 1998 REQUEST	**13,500.0**	**5,326.5**	**5,642.0**	**2,513.2**	**18.3**
VA-HUD INDEPENDENT AGENCIES APPROPRIATIONS ACT, FY 1998 (P.L. 105-205) AS PASSED BY CONGRESS, DIRECTION INCLUDED IN CONFERENCE REPORT H.R. 105-297	**138.0**	180.0	38.0	-80.0	
ANTICIPATED APPROPRIATIONS TRANSFER AUTHORITY	**0.0**	173.0	-128.0	-45.0	
TOTAL FY 1998 BUDGET PLAN	**13,638.0**	**5,679.5**	**5,552.0**	**2,388.2**	**18.3**

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1999 ESTIMATES

DISTRIBUTION OF PROGRAM AMOUNT BY INSTALLATION
(Thousands of Dollars)

	Total			Human Space Flight			Science, Aeronautics and Technology			Mission Support		
	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
Johnson Space Center	4,271,372	4,367,753	4,059,293	3,802,521	3,942,300	3,596,900	90,571	82,871	107,044	378,280	342,582	355,349
Kennedy Space Center	563,125	583,024	854,904	281,400	294,200	398,100	35,285	47,376	204,430	246,440	241,448	252,374
Marshall Space Flight Center	2,555,180	2,342,428	2,279,319	1,463,046	1,302,775	1,327,800	713,427	658,708	547,540	378,707	380,945	403,979
Stennis Space Center	188,692	155,066	146,382	52,200	44,100	41,700	87,930	57,863	49,558	48,562	53,103	55,124
Ames Research Center	556,109	557,925	605,417	14,935	18,900	48,700	354,383	359,228	367,509	186,791	179,797	189,208
Dryden Flight Research Center	158,589	186,386	178,356	5,400	5,600	6,000	93,905	120,061	112,123	59,284	60,725	60,233
Langley Research Center	653,015	632,473	563,344	8,700	5,500	2,700	424,036	399,562	325,175	220,279	227,411	235,469
Lewis Research Center	727,857	670,607	627,169	20,299	21,900	48,900	472,620	383,819	314,599	234,938	264,888	263,670
Goddard Space Flight Center	2,747,421	2,749,661	2,642,725	8,500	10,700	7,300	2,190,562	2,325,901	2,190,561	548,359	413,060	444,864
Jet Propulsion Laboratory	878,007	971,305	1,045,860	2,750	200	3,000	845,965	953,551	1,026,010	29,292	17,554	16,850
Headquarters	389,522	409,067	492,491	15,049	33,325	29,900	144,416	168,060	234,451	230,057	207,682	228,140
Undistributed:												
Undistributed Reduction:		-9,500	-53,500					5 000	21 600		4 500	-31,900
Construction of Facilities:												
Various locations	3,011	3,505	3,240							3,011	3,505	3,240
	[illegible]	[illegible]	[illegible]									
TOTAL NASA	13,708,671	13,638,000	13,465,000	5,674,800	5,679,500	5,511,000	5,453,100	5,552,000	5,457,400	2,564,000	2,388,200	2,476,600

* Note: This chart contains a transfer of responsibility for program management among NASA installations. Comparing FY 1998 to FY 1999, the estimates from the Lewis Research Center and the Goddard Space Flight Center reflects transfer of funding management for procurement of expendable launch vehicle services to the Kennedy Space Center.

** Note: Undistributed reductions to be taken in Mission Communication Services and Space Communication Services in FY 1998 and FY 1999.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

ADMINISTRATIVE PROVISIONS

[INCLUDING TRANSFER OF *FUNDS*]

Notwithstanding the limitation on the availability of funds appropriated for "Human space flight". "Science. aeronautics **and** technology". or "Mission support" by **this** appropriations Act. when any activity has been initiated by the incurrence **of** obligations for construction of facilities as authorized by law. such amount available for such activity shall remain available until expended. This provision does not apply to the amounts appropriated in "Mission support" pursuant to the authorization for repair, rehabilitation and modification of facilities. minor construction of new facilities and additions to existing facilitles. and facility planning and design.

Notwithstanding the limitation on the availability of funds appropriated for "Human space flight", "Science. aeronautics and technology". or "Mission support" by this appropriations Act. the amounts approprlated for construction of facilities shall remain available until September **30, [2000]** 2001.

Notwithstanding the limitation on the availability of funds appropriated for "Mission support" and "Office of Inspector General". amounts made available by **this** Act for personnel and related **costs and** travel expenses of the National Aeronautics arid Space Administration shall remain available until September 30, [1998] 1999 arid may be used to enter into contracts for training. investigations. cost associated with personnel relocation, arid for other seivices. to be provided during the next fiscal year.

[Of the funds provided to the National Aeronautics and Space Atlminlstratlon **in** this Act, the Administrator shall by November 1, 1998, make available no less than $400,000 for a study by the National Research Council, with ari interim report to he completed by June 1, 998, that evaluates. in terms of the potential Impact on the Space Statlon's assembly schedule, budget. arid capabilities, the engineering challenges posed by extravehicular activity (EVA) requirements, United States and nori-United States space launch requirements. the potential need to upgrade or replace equipment and coriiponents after assembly complete. arid the requirements to decomniisslon and disassemble the facility]

NASA *shall develop a revised appropriation structure for submission in the Fiscal Year 2000 budget* **request** *consisting of* two *basic appropriations* (the *Human Space Flight Appropriation and* **the** *Science,* Aeronautics *and* Technology *Appropriation) with a separate (third) appropriation for the Office* *of the Inspector General. The approprtattons* ***shall each*** *tnclude the planned Jill costs (dtrect* ***and*** *tndtrect* ***costs)*** *of* ***NASA's related*** *acttvttles* ***arid allow*** *NASA to shtft ctvtl servtce salartes, beneftts* ***and*** support ***between*** *and/or among approprtattons or accounts, as* ***requlred,***for **the** ***safe,*** **timely.** ***and*** *successful accompltshment* ***of*** *NASA mtsstons. (Departments of* ***Veterans*** *Affatrs and Houstng* ***arid*** *Urban Development, and Independent Agenctes Approprlattons* ***Act,*** *1998.)*

Multi-Year Budget

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1999 ESTIMATES
(IN MILLIONS OF REAL YEAR DOLLARS)

The FY 1999 multi-year budget estimate is submitted in accordance with the NASA FY 1989 Authorization Law (P.L. 100-685).

	1997 PAST YEAR	1998 CURRENT YEAR	1999 BUDGET YEAR	2000	2001	2002	2003
HUMAN SPACE FLIGHT	**5,674.8**	**5,679.5**	**5,511.0**	**5,312.0**	**5,156.0**	**4,930.0**	**4,715.0**
SPACE STATION	2,148.6	2,501.3	2,270.0	2,134.0	1,933.0	1,766.0	1,546.0
US/RUSSIAN COOPERATIVE PROGRAM	300.0	50.0					
SPACE SHUTTLE	2,960.9	2,922.8	3,059.0	2,998.0	3,049.0	2,989.0	2,989.0
PAYLOAD UTILIZATION AND OPERATIONS	265.3	205.4	182.0	180.0	174.0	175.0	180.0
SCIENCE, AERONAUTICS AND TECHNOLOGY	**5,453.1**	**5,552.0**	**5,457.4**	**5,530.4**	**5,726.4**	**5,917.4**	**6,120.4**
SPACE SCIENCE	1,969.3	1,983.8	2,058.4	2,207.4	2,308.4	2,387.4	2,568.4
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	243.7	214.2	242.0	257.0	266.0	264.0	264.0
EARTH SCIENCE	1,361.6	1,367.3	1,372.0	1,492.0	1,494.0	1,449.0	1,407.0
AERONAUTICS & SPACE TRANSPORTATION TECHNOLOGY	1,339.5	1,470.9	1,305.0	1,092.0	1,026.0	1,057.0	1,071.0
MISSION COMMUNICATION SERVICES	418.6	395.8	380.0	382.0	382.0	380.0	380.0
ACADEMIC PROGRAMS	120.4	120.0	100.0	100.0	100.0	100.0	100.0
FUTURE PLANNING (SPACE LAUNCH)					150.0	280.0	330.0
MISSION SUPPORT	**2,564.0**	**2,388.2**	**2,476.6**	**2,415.6**	**2,412.6**	**2,526.6**	**2,579.6**
SAFETY, MISSION ASSURANCE, ENGINEERING AND ADVANCED CONCEPTS	38.8	37.8	35.6	35.6	35.6	39.6	39.6
SPACE COMMUNICATION SERVICES	291.4	194.2	177.0	136.0	125.0	151.0	121.0
RESEARCH AND PROGRAM MANAGEMENT	2,078.5	2,033.8	2,099.0	2,079.0	2,087.0	2,171.0	2,254.0
CONSTRUCTION OF FACILITIES	155.3	122.4	165.0	165.0	165.0	165.0	165.0
INSPECTOR GENERAL	**16.8**	**18.3**	**20.0**	**20.0**	**20.0**	**20.0**	**20.0**
TOTAL	**13,708.7**	**13,638.0**	**13,465.0**	**13,278.0**	**13,315.0**	**13,394.0**	**13,435.0**

Human Space Flight

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT

FISCAL YEAR 1999 ESTIMATES

GENERAL STATEMENT

GOAL STATEMENT

The Human Space Flight program is the key component of **NASA's** Human Exploration and Development of Space (HEDS) Enterprise, which has as its ultimate mission to open the space frontier by exploring, using arid enabling the development of space. Our current programs provide safe, assured transportation to and from space for people and payloads, and develop and operate habitable space facilities in order to enhance scientific knowledge, support technology development, and enable commercial activity. The four major goals of the Human Space Flight program are the following:

- Increase human knowledge of nature's processes using the space environment
- Explore the solar system
- Achieve routine space travel
- Enrich life on Earth through people living and working in space

STRATEGY FOR ACHIEVING GOALS

In Human Space Flight, we are committed to ensuring effective, efficient and safe transportation to and from space, while continually seeking to improve the safety margin of the Space Shuttle. We are actively probing our process in order to reduce operational costs, improve performance on development projects and to selectively enhance capabilities to meet customer needs

As we expand our capabilities for allowing humans to live and work continuously in space, we are transitioning our research from the Shuttle-borne Spacelab, to the conduct of joint space activities with Russia aboard the Mir, to the International Space Station.

Human Space Flight, through the utilization of Space Shuttle and Space Station, provides the capabilities to enable the development of advanced space systems, technologies, and materials. In meeting these capabilities, we will ensure that our workforce, our most important resource, will have management support to meet operational and future program requirements through career development training and employee recognition programs.

Recognizing the national benefits derived from past space activities, we will continue to emphasize the Human Space Flight program's contribution to the national community. These contributions will be implemented by contributing to science and engineering educational opportunities for our youth, and in space through support of collaborative relationships with industry and by improving the nation's quality of life by making advanced technology, directly and through "spinoffs", available to the private sector.

Human space flight achievements in exploration and development of space have paved the way for enhancing our nation's leadership in expanding the human presence in space. The necessity to fly safely and the requirement to satisfy payload customer needs, while striving to reduce operations costs will be the dominant programmatic thrusts throughout the next decade. Our success in achieving Human Space Flight goals and objectives will play a central role in leading our Nation to future technological advances for humans as they further expand their presence in space.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT

FISCAL YEAR 1999 ESTIMATES
(IN MILLIONS OF REAL YEAR DOLLARS)

	BUDGET PLAN		
	FY 1997	FY 1998	FY 1999
HUMAN SPACE FLIGHT	**5,674.8***	**5,679.5****	**5,511.0**
SPACE STATION	2,148.6	2,501.3	2,270.0
US/RUSSIAN COOPERATION	300.0	50.0	--
SPACE SHUTTLE	2,960.9	2,922.8	3,059.0
PAYLOAD AND UTILIZATION OPERATIONS	265.3	205.4	182.0

* FY 1997 estimates reflect the "pro forma" restatement of Space Station Research Facilities funded in the Science, Aeronautics and Technology appropriation. This restatement is provided for comparability purposes.

** FY 1998 estimates reflect the effects of transferring funds from the enacted levels in P.L. 105-65 for the Mission Support (MS) and Science, Aeronautics and Technology (SAT) appropriations to the Human Space Flight (HSF) appropriation. A legislative proposal is being submitted for the purpose of providing transfer authority between the HSF appropriation and the MS and SAT appropriations.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

HUMAN SPACE FLIGHT

For **necessary** expenses. not otherwise provided for. **in** the conduct **arid** support of human space flight research arid development activities. including research, development. operations. and services; maintenance; coristructlon of facilities including repair. rehabilitation. **arid** modification **of** real **and** personal property. and acquisition or condemnation of real property. as authorized by law; space flight, spacecraft control and communications activities including operations. production. and seivices; and purchase. lease, charter. maintenance and operation of mission and administrative aircraft, [$5,506,500,000] $5.511,000,000, to remain available until September 30. [1999: *Provided,* That of the $2,351,300,00 made available under this heading for Space Station activities, only $1,500,000,000 shall be available before March 31, **19981** *2000.*

*For **necessary expenses** of **the** International **Space** Station, to become available on October 1 of the fiscal year specified and remain available for that **and** the following fiscal **year,** as follows; for fiscal year 2000, $2,134,000,000; for fiscal **year** 2001, $1,933,000,000; for fiscal **year** 2002, $1,766,000,000; for fiscal year 2003, **$1,546,000,000;** and for fiscal year 2004, $350,000,000. (Departments of **Veterans** Affairs and Housing and **Urban Development, arid Independent** Agencies Appropriations **Act,** 1998.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT

REIMBURSABLE SUMMARY
(IN MILLIONS OF REAL YEAR DOLLARS)

	BUDGET PLAN		
	FY 1997	FY 1998	FY 1999
HUMAN SPACE FLIGHT	**68.5**	**71.0**	***200.0***
SPACE STATION	--	.2	.7
US/RUSSIAN COOPERATION	--	--	--
SPACE SHUTTLE	34.5	30.9	75.6
PAYLOAD AND UTILIZATION OPERATIONS	34.0	39.9	123.7

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1999 ESTIMATES

DISTRIBUTION OF HUMAN SPACE FLIGHT BY INSTALLATION
(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Ames Research Center	Dryden Flight Research Center	Langley Research Center	Lewis Research Center	Goddard Space Flight Center	Jet Propulsion Lab	Headquarters
Space Station	1997	2,148,600	1,940,500	68.500	93,300	0	14,800	0	7,200	19,200	500	400	4.200
	1998	2,501,300	2,234,900	86,300	118,600	0	18.900	0	5,500	21,900	0	200	15,000
	1999	2,270,000	1,862,600	96,700	182,800	0	48,700	0	2,700	48.900	0	3,000	24,600
U.S.-Russian Cooperative Program	1997	300,000	297,200	2,400	300	0	0	0	0	0	100	0	0
	1998	50,000	50,000	0	0	0	0	0	0	0	0	0	0
	1999												
Space Shuttle	1997	2,960,900	1,473,600	142,900	1.276.500	50,500	0	5,400	1,000	800	500	2,100	7.600
	1998	2,922,800	1,574,500	160,000	1,136,400	42,700	0	5.600	0	0	0	0	3.600
	1999	3,059,000	1,685,800	227.800	1,096,200	40,200	0	6,000	0	0	0	0	3,000
Payload **and** Utilization Operations	1997	265,300	91,221	67,600	92,946	1,700	135	0	500	299	7,400	250	3.249
	1998	205,400	82,900	47,900	47,775	1,400	0	0	0	0	10.700	0	14,725
	1999	182,000	48,500	73.600	48,800	1,500	0	0	0	0	7,300	0	2,300
TOTAL HUMAN SPACE FLIGHT	1997	5,674,800	3,802,521	281,400	1,463,046	52.200	14,935	5,400	8,700	20.299	8,500	2,750	15.049
	1998	5,679,500	3,942,300	294,200	1,302,775	44,100	18,900	5,600	5.500	21,900	10,700	200	33.325
	1999	5,511,000	3,596,900	398,100	1,327,800	41,700	48,700	6,000	2,700	48,900	7.300	3.000	29,900

Space Station

HUMAN SPACE FLIGHT

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **SPACE STATION**

SUMMARY OF RESOURCES REQUIREMENTS*

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
Development	1,809,900	1,789,900	1,055,500	HSF 1-4
Operations	142,600	490,100	840,300	HSF 1-17
Research	196,100	221,300	374,200	HSF 1-22
Total	2,148,600	2,501,300	2,270,000	
Distribution of Program Amount by Installation				
Johnson Space Center	1,940,500	2,234,900	1,862,600	
Kennedy Space Center	68,500	86,300	96,700	
Marshall Space Flight Center	93,300	118,600	182,800	
Ames Research Center	14,800	18,900	48,700	
Langley Research Center	7,200	5,500	2,700	
Lewis Research Center	19,200	21,900	48,900	
Goddard Space Flight Center	500	--	--	
Jet Propulsion Laboratory	400	200	3,000	
Headquarters	4,200	15,000	24,600	
Total	2,148,600	2,501,300	2,270,000	

* Summary adjusted to reflect restructured budget in FY 1997, and prospective transfer authority and reallocations in FY 1998:

	FY 1997	FY 1998
Space Station operating plans	2,017,200	2,301,300
Research elements budget in science, aeronautics & technology	131,400	
Prospective transfer authority		173,000
Prospective reallocations from human space flight	--	27,000
Space Station FY 1999 budget estimates	2,148,600	2,501,300

PROGRAM GOALS

The goal of the International Space Station (ISS) is to determine the feasibility and desirability of future human exploration. It provides a long-duration habitable laboratory for science and research activities which allow investigation of the limits of human performance, vastly expand human experience in living and working in space, and provide the capability to understand whether there are additional opportunities for the large-scale commercial development of space. The ISS will provide a capability to perform unique, long duration, space-based research in cell and developmental biology, plant biology, human physiology, fluid physics, combustion science, materials science and fundamental physics. ISS will also provide a unique platform for making observations of the Earth's surface and atmosphere, the sun, and other astronomical objects. The experience and dramatic results obtained from the use of the ISS will guide the future direction of the Human Exploration and Development of Space Enterprise, one of NASA's key strategic areas. The Space Station is key to NASA's ability to fulfill its mission to explore, use, and enable the development of space for human enterprise.

STRATEGY FOR ACHIEVING GOALS

The Space Station is unique because it will provide the world with a permanent international outpost in space. The schedule for the current design emphasizes an early permanent crew capability that provides an advanced research laboratory for use by international crews for extended durations. Therefore, early into the program, the Space Station will provide the capability to stimulate new technologies, enhance industrial competitiveness, further commercial space enterprises, and add greatly to the storehouse of scientific knowledge.

The ISS is the culmination of the redesign work begun in FY 1993 to increase efficiency and effectiveness in response to lower projections for the Agency budget and growing emphasis on other programs. Human presence in space is one of NASA's highest priorities, and the redesigned Space Station has met the President's goal to reduce program costs while still providing significant research capabilities. The current management approach in which a single contractor, Boeing, has total prime and integration responsibilities with the previous prime contractors (McDonnell Douglas, Rocketdyne, and Boeing Huntsville) now performing program responsibilities under the Boeing corporate structure. This has resulted in clearer lines of authority and greater accountability along with increased efficiency. Program management of the ISS is located in Houston, Texas.

The baseline program content includes development, operations and research, which includes Space Shuttle-Mir activities, science payload facilities, and utilization related to the Space Station. Extensive coordination with the user community is ongoing with payload facilities development and research and technology activities being coordinated with the Office of Life and Microgravity Sciences and Applications (OLMSA) and the Office of Mission to Planet Earth (OMTPE).

NASA has consolidated the management of Space Station research and technology, science utilization, and payload development with the Space Station development and operations programs in order to enhance the integrated management of the total content of the budget. The Space Station program manager is responsible for the cost, schedule and technical performance of the total program. The OLMSA and OMTPE remain responsible for establishing the research requirements to be accommodated on the

Space Station and will respond to the direction of the program manager to ensure the utilization priorities and requirements are consistent with the overall Space Station objectives. This total budget is funded within the Space Station budget line of the Human Space Flight appropriation account.

Funding in FY 1998 reflects the additional $100 million and the reallocated $80 million from the Mission Support appropriation, as provided for in P.L. 105-65. Funding in FY 1998 also reflects prospective transfer authority of $173 million and additional reallocations of $27 million for the Space Station. The program is planning work activity in FY 1998 based on these funding assumptions. The NASA operating plan reflecting the $180 million appropriation increase was submitted in January 1998. A supplemental appropriation and revised operating plan requesting the required transfer authority and reallocations will be submitted by the Administration.

Of the $173 million to be sought in transfer authority, NASA plans to transfer $73 million upon enactment by Congress with the remaining $100 million provided later, as warranted. Any future budget growth will be offset within the Human Space Flight appropriation.

International participation in the Space Station program was initiated in 1984 with invitations issued by President Reagan to Europe, Japan and Canada. With the U.S. playing the lead role, the international partnership invited Russia to participate in the program in 1993. As a result, Space Station cooperating agencies now include NASA, the Russian Space Agency (RSA), the Canadian Space Agency (CSA), the European Space Agency (ESA), and the National Space Development Agency of Japan (NASDA). International participation in the program has significantly enhanced the capabilities of the ISS. Through FY 1996, the CSA, ESA and NASDA have invested nearly **$6** billion for design and development, and anticipate a total expenditure of $10 billion. In accordance with the terms of the agreements, the U.S. and our international partners will share the total available resources and the common costs for operations. The ISS represents an unprecedented level of international cooperation.

Recently, under a bilateral agreement with the U.S., the Brazilian Space Agency **(AEB)** has become a participant in the U.S. ISS program. Brazil's contributions help fulfill a portion of U.S. obligations to the ISS program in exchange for access to the U.S. share of ISS resources. Similarly, on a bilateral basis, NASA and the Italian Space Agency have recently signed an updated MOU for Italy's provision of three multi-purpose logistics modules. Additionally in a September 1997 Agreement in Principle with NASDA a Centrifuge, Centrifuge Accommodation Module (CAM), and Life Sciences Glovebox will be provided as an offset for the Shuttle launch of the Japanese Experiment Module (JEM). This fall an Agreement in Principle was signed with ESA that will provide Nodes 2 and **3** as an offset for the Shuttle launch for the Attached Pressurized Module (APM).

Development of the Space Station program **is** being conducted in a phased approach. The initial phase, which will be concluded this year, includes nine Shuttle-Mir docking missions. The goals of this initial phase are to develop and demonstrate joint mission procedures with Russia, to gain valuable experience to reduce technical risk during International Space Station construction, and to provide early opportunities for extended scientific research.

The next phase of the program begins with the scheduled launch of the U.S.-owned/Russian-launched functional cargo block (FGB) in June 1998, and concludes with the launch of the Airlock on Flight **7A.** Permanent crew capability for three persons is possible upon delivery of the Soyuz in January 1999. Microgravity capability will be available in June 1999, with the outfitting **of** the U.S. laboratory. At completion of this phase in August 1999, the Station configuration will include the U.S. node, laboratory, pressurized mating adapters, power, airlock and mini-pressurized logistics module (MPLM); Russian FGB, service module and Soyuz; and the Space Station remote manipulator system (SSRMS) provided by Canada.

By the end of FY 2002 the Station configuration will include the **U.S.** Laboratory, the second and third **U.S.** nodes, cupola, truss elements, three solar arrays, the Japanese Experimental Module (JEM), a Russian research module, docking and life support modules, and resupply/support vehicles. By the end **of** CY 2003, planned activities include the delivery to orbit **of** the ESA Attached Pressurized Module (APM)*, a second Russian research module, a crew return vehicle (CRV), the fourth solar array, Centrifuge Accommodation Module (CAM)/Centrifuge, and the U.S. Habitation Module. Routine logistics module launches to the Space Station will continue over the remaining lifetime of the Station. Delivery of the crew return vehicle and the final outfitting flight will mark the beginning of the permanent 6-member crew capability. Delivery of the Habitation Module will signal the initiation of the permanent 7-member crew capability.

*Attached pressurized module (APM) is the new name for Columbus Orbital Facility (COF).

BASIS OF FY 1999 FUNDING REQUIREMENT

SPACE STATION DEVELOPMENT

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Flight hardware	1,540,700	1,529,000	931,400
Test, manufacturing and assembly	95,700	97,400	33,700
Operations capability and construction	115,700	115,100	64,300
Transportation support	55,700	47,000	26,100
Flight technology demonstrations	2,100	1.400	--
Total	1.809.900	1.789.900	1,055,500

PROGRAM GOALS

Development of the International Space Station (ISS) will provide an on-orbit, habitable laboratory for science and research activities, including flight and test hardware and software, flight demonstrations for risk mitigation, ground operations capability and facility construction, shuttle hardware and integration for assembly and operation of the station, mission planning, and integration of Space Station systems.

STRATEGY FOR ACHIEVING GOALS

Responsibility for providing Space Station elements is shared among the U.S. and our international partners from Russia, Europe, Japan, and Canada. The U.S. elements include three nodes, a laboratory module, airlock, truss segments, four photovoltaic arrays, a habitation module, three pressurized mating adapters, unpressurized logistics carriers, and a cupola. Various systems are also being developed by the U.S., including thermal control, life support, navigation and propulsion, command and data handling, power systems, and internal audio/video. The U.S. funded elements also include the FGB energy tug being constructed by a Russian firm under the Boeing prime contract. Other **U.S.** elements include the pressurized logistics modules provided by the Italian Space Agency and equipment and research facilities provided by the Brazilian Space Agency.

Canada, member states of the European Space Agency (ESA), Japan, and Russia are also responsible for providing a number of ISS elements. Laboratory modules will be provided by the Japanese, ESA, and Russia. Canada will provide a remote manipulator system, vital for assembly of the station. The Russian Space Agency (RSA) is also providing significant ISS infrastructure elements including the science power platform, life support modules, Soyuz crew transfer vehicle, Progress resupply vehicles, and universal docking modules.

The Boeing company is the prime contractor for the Space Station with responsibility for integration and assembly of the ISS. At their Huntington Beach site location (formerly McDonnell Douglas), Boeing is developing and building the integrated truss segments that separate station elements and house essential systems, including central power distribution, thermal distribution and attitude control equipment. Radiators, communications antennas, and the Space Station robotic manipulator system are also mounted to truss segments. Additionally major components of the communications and data handling, thermal control, and the guidance, navigation and control subsystems are being developed at Huntington Beach.

U.S. pressurized volumes are being developed by Boeing at their Huntsville site location. After the first element launch of the FGB energy block in June 1998, the next flight in July 1998, will launch Node 1, a pressurized volume which contains four radial and two axial berthing ports. The node will be launched with two pressurized mating adapters (PMAs) attached and will serve as the docking location for the delivery of the U.S. laboratory module and the pressurized logistics module. Node 2 is currently manifested for flight during April 2001, the Cupola is manifested for flight during May 2002, and Node **3** is manifested for flight during July 2002. The final U.S. pressurized volume is the habitation module which will contain the galley, wardroom, waste management, water processing and other crew support functions necessary for human operations.

The power truss segments and power system, essential to the Station's housekeeping operations and scientific payloads, is being built by Boeing at their Canoga Park site location (formerly Rocketdyne Division, Rockwell International). Four photovoltaic elements containing a mast, rotary joint, radiator, arrays, and associated power storage and conditioning elements which make up the power system are being .developed.

The development program also includes test, manufacturing and assembly support for critical NASA center activities and institutional support. These "in-line" products and services include: test capabilities: the provision of govemment-furnished equipment (GFE), including flight crew systems, environment control and life support systems, communications and tracking, and extravehicular activity (EVA) equipment; and, engineering analyses. As such, they support the work of the prime contractor, its major subcontractors and NASA system engineering and integration efforts.

Operations capability and construction provides for the development of a set of facilities, systems and capabilities to conduct the operations of the Space Station. The work will be performed at the Kennedy Space Center (KSC) and the Johnson Space Center (JSC). The KSC will develop launch site operations capabilities for conducting pre-launch and post-landing ground operations. JSC will develop space systems operation capabilities for conducting training and on-orbit operations control of the Space Station. Construction of the neutral buoyancy laboratory (NBL) in Houston has been completed, and it now provides the capability for Space Station crew training that meets the requirement for simultaneous EVA training (up to nine crew members at a time).

The redesigned Space Station emphasizes multicenter and multiprogram cooperation. At JSC, a consolidated approach between Space Shuttle and Space Station minimizes duplicated effort and costs for command , control and training. Crew training will be based on a detailed risk analysis to determine the optimum failure response training profile. Therefore, training will be knowledge- and proficiency-based rather than driven by timeline and detailed procedures rehearsal.

Transportation support provides those activities which allow the Space Shuttle to dock with the Space Station. This budget supports development and procurement of two external Shuttle airlocks, and upgrade of a third airlock to full system capability, which are required both for docking the Space Shuttle with the Russian Mir and for use with the Space Station. Other items in this budget include: the Shuttle remote manipulator system (RMS) and Space Shuttle mission training facility upgrades; development of a UHF communications system and a laser sensor; procurement of an operational space vision system; procurement of three docking mechanisms and Space Station docking rings: EVA/Extravehicular Mobility Units (EMU) services and hardware; and integration costs to provide analyses and model development.

Space Station technology and system validation funding requirements include flight technology demonstrations, flown during Phase I, in areas of joint NASA/RSA development that pose a level of technical or programmatic risk warranting additional verification. Risk areas include life support, the data processing system, automatic rendezvous and docking, vibration isolation in a microgravity environment, assembly and maintenance, loads and dynamics, contamination, radiation environment, and micrometeoroid/orbital debris. In addition, funding is provided for operational techniques development for procedures, utilizing the Space Shuttle flights to the Russian Mir Space Station, that will benefit the future operational phases of the ISS program.

MEASURES OF PERFORMANCE

Completed Incremental Design Review (IDR)

Performed Stage Integration Reviews (SIR)

A series of incremental, cumulative reviews throughout the design phase to assure that system level requirements are properly implemented in the design, have traceability, and that hardware and software can be integrated to support staged assembly and operation. IDR #1 performed these functions for flights 1A through 6A. Subsequently, IDR#2 assessed design progress for flights 1A through 7A. IDR#2B assessed the entire Space Station assembly sequence.

IDRs have been replaced by a more classical Critical Design Review (CDR) approach on a stage-by-stage basis, which review groupings of flights with assembly hardware and functionality/performance linkages across the stage.

- Performed SIR 1 for flights through 2A (4th Qtr FY 1997)
- Performed SIR 2 for flights through 4A (1st Qtr FY 1998)
- Perform SIR 3 for flights through 6A (2nd Qtr FY 1998)
- Perform SIR 4 for flights through 4R (4th Qtr FY 1998)

Prime Development Activity **NOTE: All activities listed are planning milestones, and are not contractual.**

Flight 1A/R:
FGB Energy Block
(First Element Launch)
(Proton Launch Vehicle)
Planned: November 1997
Revised: June 1998

Self-powered, active vehicle: provides attitude control through early assembly stages; provides fuel storage capability after the service module is attached; provides rendezvous and docking capability.

- Completed factory ground testing of first flight unit (slip from 3^{rd} Qtr FY 1997 to 4^{th} Qtr FY 1997)
- Complete flight software (slip from 3^{rd} Qtr FY 1997 to 1st Qtr FY1998)
- Deliver FGB flight article to Baikanour (slip from 3^{rd} Qtr FY 1997 to 2^{nd} Qtr FY 1998)
- Install solar arrays in FGB flight article (slip from 1^{st} Qtr FY 1998 to 3^{rd} Qtr FY 1998)
- Mating of FGB to Launch Vehicle (slip from 1^{st} Qtr FY 1998 to 3^{rd} Qtr FY 1998)
- On-Orbit checkout, Service Module docking, fuel transfer (slip from 1^{st} Qtr FY 1998 to 3^{rd} Qtr FY 1998)

Flight 2A:
Node 1, Pressurized Mating Adapters (PMA-1, PMA-2)
Planned: December 1997
Revised: July 1998

Initial U.S. pressurized element, launched with PMA-1, PMA-2, and 1 stowage rack: PMA-1 provides the interfaces between U.S. and Russian elements: PMA-2 provides a Space Shuttle docking location.

- Completed Node Structural Test Article (STA) proof pressure/leak rate qualification testing 1^{st} Qtr FY 1997)
- Began engineering, fabrication, assembly, set-up and preparation for node STA modal survey test (1^{st} Qtr FY 1997)
- Completed installation of mechanical equipment into Node 1 flight article primary structure (1^{st} Qtr FY 1997)
- Began final assembly and outfitting of all major components of Node 1 flight article (1^{st} Qtr FY 1997)
- Completed STS-88 Cargo Integration Review (1^{st} Qtr FY 1997)
- Completed pressurized mating adapter (PMA-1) shell (slip from 1^{st} Qtr FY 1997 to 2^{nd} Qtr FY 1997)
- Completed PMA-2 shell (2^{nd} Qtr FY 1997)
- Completed design and fabrication of Node 1 flight article external secondary structure (Slip from 2^{nd} Qtr FY 1997 to 3^{rd} Qtr FY 1997)
- Began PMA-1 acceptance test (slip from 2^{nd} Qtr FY 1997 to 3^{rd} Qtr FY 1997)
- Began PMA-2 acceptance test (slip from 2^{nd} Qtr FY 1997 to 4^{th} Qtr FY 1997)
- Stage Integration Review #1 (slip from 2^{nd} Qtr FY1997 to 4^{th} Qtr FY 1997)
- PMA 1 & 2 on dock at KSC (slip from 3^{rd} Qtr FY 1997 to 4^{th} Qtr FY 1997)
- Complete Node 1 acceptance test (slip from 3^{rd} Qtr FY 1997 to 2^{nd} Qtr FY 1998)

- Node 1 on dock at KSC (3rd Qtr FY 1997)
- Complete Node STA static flight loads testing (slip from 4th Qtr FY 1997 to 1st Qtr FY 1998)
- Complete Flight 2A Cargo Element Integration and Test (slip from 1st Qtr FY 1998 to 2nd Qtr FY 1998)
- Space Shuttle Payload Integration and Test (slip from 1st Qtr FY 1998 to 4th Qtr FY 1998)

Flight 2A.1 Logistics Planned: December 1998	Double Spacehab flight for logistics during early assembly; equipment to further outfit the service module. • Increment Definition and Requirements Document (IDRD) baselined (4th Qtr FY 1997) • Station Cargo Integration Review (SCIR) (2nd Qtr FY 1998) • Flight Operations Review (FOR) (3rd Qtr FY 1998) • Hardware on'dock at KSC (4th Qtr FY 1998)
Flight 3A Z1 Truss Segment, Control Moment Gyros (CMGs), PMA-3, KU-Band Planned: July 1998 Revised: January 1999	Z1 Truss allows temporary installation of the P6 photovoltaic module to Node 1 for early U.S. based power; KU-band and CMGs support early science capability: PMA-3 provides a Space Shuttle docking location for the lab installation on flight 5A. • Completed CMG qualification testing (2nd Qtr FY 1997) • Began assembly of 3A Flight Model DDCUs (slip from 1st Qtr FY 1997 to 4th Qtr FY 1997) • Z1 qualification structure fabrication and assembly completed (slip from 2nd Qtr FY 1997 to 3rd Qtr FY 1997) • Completed flight article CMG acceptance test for flight unit #1 (slip from 2nd Qtr FY 1997 to 4th Qtr FY 1997) • Z1 modal and static qualification tests complete (slip from 4th Qtr FY 1997 to 1st Qtr FY 1998) • PMA-3 on-dock at KSC (Slip from 4th Qtr FY 1997 to 2nd Qtr FY 1998) • KU-Band on dock at KSC (2nd Qtr FY 1998) • S-Band on dock at KSC (2nd Qtr FY 1998) • Z1 final assembly and test (3rd Qtr 1998)

Flight 4A:
P6 Truss segment,
Photovoltaic Array,
Thermal Control System
(TCS)Radiators, S-Band
Equipment
Planned: November 1998
Revised: April 1999

Establishes initial U.S. photovoltaic module based power capability: installed in a temporary location on top of the Z1 truss until flight **13A** when it is permanently attached to the P5 truss: includes 2 TCS radiators for early active thermal control.

- Completed mechanical installation and outfitting of integrated electronics assembly (IEA) qualification unit (1st Qtr FY 1997)
- Completed E-wing life cycle testing (1st Qtr FY 1997)
- Completed assembly of P6 IEA qualification unit (1st Qtr FY 1997)
- Completed IEA qualification unit hardware/software integration and functional testing (1st Qtr FY 1997)
- Began P-6 long spacer flight hardware fabrication/assembly (1st Qtr FY 1997)
- Began thermal balance testing of IEA qualification unit (2nd Qtr FY 1997)
- Completed fabrication and assembly of P6 long spacer qualification unit (slip from 3rd Qtr FY 1997 **to** 4th Qtr FY 1997)
- Completed IEA flight unit fabrication (slip from 3rd Qtr FY 1997 to 4th Qtr FY 1997)
- P6 long spacer on dock at KSC (2nd Qtr FY 1998)
- IEA to KSC (2nd Qtr FY 1998)
- Complete flight qualification IEA testing (3rd Qtr FY 1998)
- PV Arrays flight units on dock at KSC (3rd Qtr FY 1998)

Flight 5A:
U.S. Laboratory,
5 Lab System Racks
Planned: December 1998
Revised: May 1999

Establishes initial U.S. user capability: launches with 4 system racks preintegrated; KU-band and CMGs are activated.

- Began laboratory common module STA qualification testing (1st Qtr FY 1997)
- Completed development of lab flight article pressure vessel (2nd Qtr FY 1997)
- Completed Mission Integration Plan Baseline (slip from 2nd Qtr FY 1997 to 4th Qtr FY 1997)
- Complete Flight 5A Stage Integration Review (slip from 4th Qtr FY 1997 to 2nd Qtr FY 1998)
- Complete lab racks, crew systems, closeouts, and hatch installation (slip from 1st Qtr FY 1998 to 3rd Qtr FY 1998)
- Complete Cargo Integration Review (slip from 1st Qtr FY 1998 to 3rd Qtr 1998)
- Complete Lab hardware/software integration (3rd Qtr FY 1998)
- Lab on dock at KSC (4th Qtr FY 1998)

Flight ***6A***
Mini-Pressurized Logistics Module, Canadian Remote Manipulator System, UHF
Planned: January 1999
Revised: June 1999

Adds U.S. lab outfitting with 1 stowage and 7 systems racks: UHF antenna provides space-to-space communication capability for U.S. based EVA: manifests Canadian SSRMS needed to perform assembly operations on later flights.

- Completed MPLM System Critical Design Review (2^{nd} Qtr FY 1997)
- Delivered SSRMS Structural Test Article to NASA (slip from 2^{nd} Qtr FY1997 to 3^{rd} Qtr FY 1997)
- Baselined Flight 6A Mission Integration Plan (slip from 2^{nd} Qtr FY 1997 to 4^{th} Qtr FY 1997)
- Complete MPLM FM1 structure manufacturing and assembly (slip from 3^{rd} Qtr FY 1997 to 1^{st} Qtr FY 1998)
- Complete Stage Assessment Integration Review (slip from 4^{th} Qtr FY 1997 to 2^{nd} Qtr FY 1998)
- Begin integration of Spacelab Logistics Pallet Cargo Element (slip from 2^{nd} Qtr FY 1998 to 3^{rd} Qtr FY 1998)
- Deliver MPLM to KSC (3^{rd} Qtr FY 1998)
- Cargo Integration Review (slip from 2^{nd} Qtr FY 1998 to 4^{th} Qtr FY 1998)
- Remove 6A racks from Lab at KSC (slip from 4^{th} Qtr FY 1998 to 2^{nd} Qtr FY 1999)
- Complete Flight Operations Review (slip from 4^{th} Qtr FY 1998 to 2^{nd} Qtr FY 1999)

Flight 7A:
Airlock
HP Gas
Plan: August 1999

Launches the airlock and installs it on orbit. The addition of the airlock permits ISS-based EVA to be performed without loss of environmental consumables such as air.

- Completed proof press test (4^{th} Qtr FY 1997)
- Airlock structure delivery to outfitting team (4^{th} Qtr FY 1998)
- Outfitting element level qualification test complete (2^{nd} Qtr FY 1999)
- Airlock on dock at KSC (2^{nd} Qtr FY 1999)
- Complete SLP integration (3^{rd} Qtr FY 1999)

Flight **7A.**1
MPLM
SLP pallet
Planned: November 1999

Logistics and utilization mission delivering resupply/return stowage racks, resupply stowage platforms, photovoltaic batteries, battery charge and discharge (BCDC) units, and an orbital replaceable unit (ORU) device

- IDRD baseline (3^{rd} Qtr FY 1998)
- MPLM hardware on dock at KSC (4^{th} Qtr FY 1998)
- SCIR (1^{st} Qtr FY 1999)
- FOR (3^{rd} Qtr FY 1999)

Flight 8A:
SO Truss
Mobile Transporter
Plan: February 2000

S0 is the truss segment which provides attachment and umbilicals between pressurized elements and truss mounted distributed systems/utilities. Mobile Transporter provides SSRMS translation capability along the truss.

- Complete S0 STA fabrication and assembly (1^{st} Qtr FY 1998)
- Complete S0 STA outfitting (2^{nd} Qtr FY 1998)
- Complete S0 STA structural testing (2^{nd} Qtr FY 1999)
- Complete ***SO*** flight fabrication and assembly (3^{rd} Qtr FY 1998)
- S0 on dock at KSC (1^{st} Qtr FY 1999)
- Complete ***SO*** integrated testing (3^{rd} Qtr FY 1999)
- Complete Mobile Transporter structural test article (1^{st} Qtr FY 1998)
- Complete Mobile Transporter flight article (3^{rd} Qtr FY 1998)

Flight 9A:
S1 Truss
CETA Cart
Plan: June 2000

S1 truss provides permanent active thermal control capability. Crew and Equipment Translation Aid (CETA) cart provides EVA crew translation capability along the truss.

- Complete S1 **STA** fabrication and assembly (3^{rd} Qtr FY 1998)
- Complete S1 STA outfitting (4^{th} Qtr FY 1998)
- Complete S1 STA structural testing (4^{th} Qtr FY 1999)
- Complete S1 flight fabrication and assembly (4^{th} Qtr FY 1998)
- S1 on dock at KSC (2^{nd} Qtr FY 1999)
- Complete S1 integrated testing (4^{th} Qtr FY 1999)

Non-Prime Development Activity

Global Positioning System (GPS)

Provides autonomous, real-time determination of Space Station's position, velocity, and attitude of absolute time

- Delivered GPS Antenna Assembly (4^{th} Qtr FY 1997)
- Deliver GPS Receiver/Processor (slip from 3^{rd} Qtr FY 1997 to 4^{th} Qtr FY 1998)

Extra-Vehicular Activity System

Provides Government Furnished Equipment (GFE),EVA unique tools, Orlan SAFER (Russian space suit), and EVA support equipment for the Space Station. Provides EVA development and verification testing. Provides for operation of the WETF/NBL and the maintenance of neutral buoyancy mockups to support Station EVA development activities.

- Delivered Orbital Support Equipment (3^{rd} Qtr FY 1997)
- Delivered Articulating Portable Foot Restraints (slip from 3^{rd} Qtr FY 1997 to 4^{th} Qtr FY 1997)
- Delivered Torque Multiplier (slip from 3^{rd} Qtr FY 1997 to 4^{th} Qtr FY 1997)
- Deliver Orlan SAFER - first 2 units (slip from 1^{st} Qtr FY 1998 to TBD)
- Deliver Temporary Equipment Restraint Aid (2^{nd} Qtr FY 1998)
- Deliver Crew Equipment Transfer Aid Cart Proto-Flight unit (slip from 1^{st} Qtr FY 1997 to 4^{th} Qtr FY 1999)

Flight Crew Systems

Provides flight and training hardware and provisions for food and food packaging development: housekeeping management: portable breathing apparatus: restraints and mobility aids, tools and diagnostic equipment and portable illumination kit.

- Completed 6A Operations and Personal Equipment CDR (1^{st} Qtr FY 1997)
- Delivered Restraints and Mobility Aids (1^{st} Qtr FY 1997)
- Completed CDR for portable illumination (2^{nd} Qtr FY 1997)
- Complete Stowage Tray Restraint CDR (slip from 2^{nd} Qtr FY 1997 to TBD)
- Complete production of tools and diagnostic flight hardware kit (slip from 1^{st} Qtr FY 1998 to 3^{rd} Qtr FY 1998)
- Complete Personal Hygiene Kit PRR Preliminary/Program Requirements Review (2^{nd} Qtr FY 1998)
- Deliver Maintenance Workstation Kit, Portable Illumination, and Housekeeping Kit (4^{th} Qtr FY 1998)

Airlock Service And Performance Checkout Unit

Provides flight servicing, performance unit, and certification unit, Russian space suit support hardware interface definition and documentation, test plans and reports, mockups, and thermal analysis.

- Completed CDR (slip from 4^{th} Qtr FY 1996 to 4^{th} Qtr FY 1997)
- Deliver Certification unit hardware to Airlock Test Article (Slip from 2^{nd} Qtr FY 1997 to 3^{rd} Qtr FY 1998)
- Complete certification unit integration test (slip from 4^{th} Qtr FY 1997 to 3^{rd} Qtr FY 1998)
- Complete flight unit acceptance test (slip from 4^{th} Qtr FY 1997 to 3^{rd} Qtr 1998)

Space Station Training Facility (SSTF)	Primary facility for space systems operations training and procedures verification. • Completed Part task trainer for Flight 1A (slip from 4th Qtr FY 1996 to 4th Qtr FY 1997) • SSTF Initial Ready for Training (RFT) for flight 2A (slip from 3rd Qtr FY 1997 to 4th Qtr FY 1997) • SSTF Initial RFT for flight 5A (slip from 4th Qtr FY 1998 to 1st QTR FY 1999) • SSTF Final RFT for Flight 5A (3rd Qtr FY 1999) • SSTF Final RFT for Flight 2A (3rd Qtr FY 1998) • SSTF Initial RFT for Flight 6A (1st Qtr FY 1999) • SSTF Final RFT for Flight 6A (3rd Qtr FY 1999) *Flightsbeyond 6A TBD for SSTF
Integrated Planning System (IPS)	Provides planning and analysis tools for pre-increment and real-time operations systems supporting trajectory/flight design, timelines, resource utilization, onboard systems, performance analyses systems operation data file procedures and control, maintenance operations, inventory and logistics planning, robotics analysis, and procedures development. • Completed delivery to support Flight 5A planning and operations (slip from 3rd Qtr FY 1997 to 4th Qtr FY 1997) • Complete delivery to support Flight 1J/A (slip from 4th Qtr FY 1997 to 4th Qtr FY 1998) • Complete ISS MOD Avionics Reconfiguration System (IMARS) development (3rd Qtr FY 1998) • Complete IPS development (3rd Qtr FY 1999)
Mission Control Center	Facility providing integrated command and control capabilities and support to real-time increment operations. • Completed Standoff Vent Fan (SVF) integration test for flights 2A-4A (slip from 2nd Qtr FY 1997 to 3rd Qtr FY 1997) • Delivery to support Flight 2A flight following capability (slip from 3rd Qtr FY 1997 to 2nd Qtr FY 1998) • Delivery to support CSA Interface and Payload Interface (3rd Qtr FY 1998) • Delivery to support Flight 5A ISS Command and Control Capability (slip from 4th Qtr FY 1998 to 1st Qtr FY 1999) • Complete backup control center (control center development complete) (3rd Qtr FY 1999) • MCC RFT for UF-1 (4th Qtr FY 1998)

ACCOMPLISHMENTS AND PLANS

FY 1997

During FY 1997 the major program focus continued to be manufacturing and testing of flight hardware to support First Element Launch (FEL) in June 1998 and subsequent launches throughout 1999. Major preparation was made in support of the FGB, Node 1, truss segments, the U.S. laboratory, and the subsystems to support these elements. The international partners continued development of flight hardware.

The U.S. effort included work on Node 1, PMA 1 and PMA 2. Key structural tests were also completed on several major U.S. elements (node static loads, Z1 static loads, integrated electronics assembly acoustic, aft common berthing mechanism, and lab modal survey).

Other accomplishments include completing the fabrication of major flight structures (Node 1, integrated electronics assembly and lab module), completion of the Mini-Pressurized Logistics Module (MPLM) critical design review (CDR), and installation **of** the lab endcone. Qualification testing for 15 percent of critical items tracked by the program was successfully completed.

Major KSC deliveries in 1997 included the Node 1 in June, and the PMA 1 in July.

FY 1998

In FY 1998 the initiation of Phase **2/3** assembly of the ISS will occur with the launch of the U.S. owned/Russian launched Functional Cargo Block (FGB). The FGB **is** a self sufficient orbital vehicle that will provide initial capabilities for propulsion, guidance, communication, electrical power and thermal control systems.

The launch of Node 1 (1 stowage rack), PMA 1 and PMA 2 by the Space Shuttle will follow in FY 1998. PMA 1 will provide a pressurized tunnel between the U.S. pressurized elements and the Russian Modules. The PMA 2 will provide a Shuttle docking location.

Planned major KSC deliveries for FY 1998 include the PMA 2, Z1 Truss, Flight IEA, Flight Long Spacer, MPLM, laboratory and laboratory racks.

FY 1999

On flight 1R, the Russian-provided service module (SM) will contain all the systems necessary for independent orbital operations and will serve as a habitat and laboratory. The SM is scheduled on a Russian launch vehicle in December 1998, but contingency options are being addressed.

Also scheduled for a December 1998 launch date is Flight 2A.1. This flight will launch the Spacehab double cargo module.

Flight 2R in FY 1999 launches a Soyuz crew transfer vehicle giving the ISS three person human permanent presence capability, and initial science research microgravity capability will follow.

Flight 3A, also in **FY** 1999, launches the first truss segment Z1, the third PMA, Ku-band, control moment gyros, S-Band equipment, and extravehicular activity subsystem (EVAS) components. The Z1 truss segment serves as a temporary location for the first photovoltaic (PV) assembly (P6).

Flight **4A** launches the **P6 Truss** structure containing the long spacer, integrated electronic assembly (IEA), **P6** photovoltaic array, and the external active thermal control system **(EATCS).** This launch establishes initial US power generation via solar arrays and provides initial **PV** thermal control.

During FY 1999 the **US** laboratory module with five system racks installed will be launched on Flight **5A.** This will provide pressurized volume that will be utilized for scientific research.

Flight **6A** in FY 1999 delivers the mini pressurized logistics module (MPLM) containing **6** lab system racks, one storage rack, and two resupply stowage platforms for the US laboratory. Flight **6A** also delivers the UHF antenna deployment mechanism, lab cradle assembly (LCA), rigid umbilical and the Space Station remote manipulator system (SSRMS), which are transported to orbit on the Spacelab logistics pallet (SLP) in the Orbiter payload bay.

Also during FY 1999, Flight **7A** will be used to launch the airlock and install it on orbit. The addition of the airlock permits ISS-based **EVA** to be performed without loss **of** environmental consumables such as air. Flight **7A** will complete Phase 2.

BASIS OF FY 1998 FUNDING REQUIREMENT

SPACE STATION OPERATIONS

	FY 1997	FY1998	FY 1999
		(Thousands of Dollars)	
Vehicle operations..	33,500	312,400	574,800
Ground and transportation operations..	109.100	177,700	265.500
Total	142,600	490,100	840,300

PROGRAM GOALS

The first objective of the operations program is to provide for the safe, reliable, and sustained operation of the Space Station and the ground and transportation operations required to plan, train, and fly the vehicle. The second major goal is to perform the operations in a simplified and affordable manner. This includes NASA's overall integration of distributed operations functions to be performed by each of the international partners in support of their elements. Space Station operations will rely on the infrastructure developed for the Space Shuttle, and the experience derived from the Space Shuttle-Mir program to develop efficient and effective operations, Finally, operations will facilitate the transition of the various elements of the International Space Station (ISS)development program to the operations program.

STRATEGY FOR ACHIEVING GOALS

In order to increase the efficiency and lower the cost of operations, vehicle, ground and transportation operations planning began early in the ISS development program. Streamlining and efficiencies with existing programs will be maximized.

Space Station vehicle operations will provide systems engineering and integration to sustain the specification performance and reliability of Space Station systems, logistics support for flight hardware and launch site ground support equipment, configuration management, and any associated procurement activity.

Vehicle operations sustaining engineering will be performed. Additionally, flight hardware and software sustaining engineering will be consolidated at the Johnson Space Center (JSC) to allow all flight hardware and software to be handled under a single contract.

Maintenance and repair costs continue to be minimized by the application of logistics support analysis to the design, resupply/return and spares procurement processes. Flight hardware spares and repair costs will continue to be reduced by establishing a maintenance and repair capability that effectively utilizes Kennedy Space Center (KSC) and original equipment manufacturers or other certified industry repair resources.

Ground operations will provide command and control, training, operations support and launch site processing. **A** unified command and control center for the Space Station includes the Mission Control Center-Houston (MCC-H) and the Mission Control Center-Moscow (MCC-M) at Kaliningrad. **As** the flight elements from Europe, Japan and Canada become operational, their respective ground operations functions will be integrated by **NASA** into the unified command and control architecture. The MCC-H will be the prime site for the planning and execution of integrated system operations of the Space Station. Communication links from both Moscow and Houston will support control activities, using the Tracking and Data Relay Satellite System (TDRSS) system and the Russian communication assets.

Flight controllers are being trained to operate the Space Station as a single integrated vehicle, with full systems capability in the training environment. Crew members are being trained in Space Station systems, operations, and other activities expected during a mission. Part-task and full hardware mockups and simulators will be used to provide adequate training for the crew prior to flight. Integrated training, consolidation of payload and systems training facilities, the concept of proficiency based learning, and onboard training will increase the efficiency of the overall training effort.

Ground operations support will provide analysis systems definition, development, and implementation to ensure that a safe and operationally viable vehicle is delivered and can be maintained. Functions include the following: vehicle design participation and assessment, operations product development, ground facility requirements and test support, ground display and limited applications development, resource planning, crew systems and maintenance, extravehicular activity (EVA), photo/TV training, operations safety assessments, medical operations tasks, mission execution and systems performance assessment, and sustaining engineering.

Cargo integration support will provide accurate, timely, and cost effective planning and layout of cargo stowage items, analytical analysis of cargo/transport systems compatibility, and physical integration of cargo items into the transport carriers and on-orbit ISS stowage systems.

Launch site processing begins prior to the arrival of the flight hardware at KSC with requirement definition and processing planning. Upon arrival at KSC, the flight hardware will undergo various processes, dependent upon the particular requirements for that processing flow. These processes may include: post delivery inspection/verification, servicing, interface testing, integrated testing, close-outs, weight and center of gravity measurement, and rack/component to carrier installation.

MEASURES OF PERFORMANCE

Publish Preliminary Flight Rules Plan: January 1997 Actual: January 1997	ISS Generic Flight Rules, Volume B Development of ISS Flight Rules continues with participation by International Partners and Shuttle.
Baseline Second Multi-Manifest Plan: April 1997 Actual: September 1997	Annual update **of** multi-increment manifest covering Program multi-lateral vehicle traffic and crew rotation plan through the assembly period.
Complete SSPF operational readiness Plan: June 1997 Actual: January 1997	Completion **of** the installation and activation of the Space Station Processing Facility (SSPF)and facility systems. Provides the capability to support launch site processing of the KSC launched cargo elements.
Complete MCC-H/Space Station Training Facility (SSTF) integrated operations training capability Plan: October 1997 Actual: October 1997	Supports the training schedule to train ground crews for real-time operations of the Space Station vehicles.
Baseline SSP 50234, Sustaining Engineering Implementation Plan Plan: January 1998	Required to ensure NASA and its contractors are providing proper skills, tools, processes, and facilities for supporting delivered flight hardware and software.
Baseline SPIP Vol. 10, Sustaining Engineering Plan: January 1998	Standard Program Implementation Plan volume 10 provides guidance on requirements to ensure provision of proper skills, tools, processes, and facilities for supporting delivered flight hardware and software.
Definitize Sustaining Engineering Contract Mod Plan: March 1998	Required to ensure prime contractor support for delivered ISS flight Hardware and software is in place.

Demonstrate MCC-H to MCC-M Command Support Capability Plan: March 1998	Development of the Mission Control Center - Houston (MCC-H) to Mission Control Center - Moscow (MCC-M) command capability re-essay for the support of Space Station Operations.
Publish MIM 98-1 Plan: April 1998	Annual update of the multi-increment manifest (MIM) covering Program multi-lateral vehicle traffic and crew rotation plan through the assembly period.
Begin MCC-H ISS flight following mode with flight 1A/R and 2A Plan: June 1998	The Mission Control Center - Houston (MCC-H) is in a flight-following mode of operations until Flight 5A, when NASA takes over primary real-time command and control of the ISS.
Publish Operations Summary 98 Plan: June 1998	Annual update to the ISSP Operations Summary, which defines basic ISS resources available for long range utilization planning.
Baseline Increment Definition & Requirements Document (IDRD) PP#3 Plan: July 1998	The IDRD includes requirements and resource allocations for Planning Period **3** which covers the 2000 timeframe.

ACCOMPLISHMENTS AND PLANS

FY 1997

In FY 1997, work continued on KSC launch site requirements definition, processing plans, and scheduling, as well as the development of ground support equipment and the test control and monitor system (TCMS). The SSPF and facility systems installation, activation, and validation continued until the operational readiness date, June 1997. The SSTF and MCC-H began crew and ground controller training for flights 1A-2A. Also during FY 1997, the integrated planning system was ready to support planning for the 1A-5A flights. The preliminary release of the increment specific flight rules and operations data file for flight 2A was produced. In FY 1997 and FY 1998, suppliers and original manufacturers were put on repair retention contracts to ensure repair of failed equipment and continued operation of ISS. Procurement of spares below the equipment level was a major thrust in FY 1997.

FY 1998

In FY 1998, the first two assembly flights (1 Russian and 1 U.S.) will occur, requiring the initiation of real-time operations support. The following recurring operations activities indicate a buildup in operations workload: ISS crew simulator training for two (2) flights: the basic release of the operations data file for five (5)flights: Shuttle mission integration plans baselined for six (6)flights; and basic release of the increment specific flight rules for *6* flights. The MCC-H will begin functioning in a flight-following mode of operation starting with the first element launch on ISS flight 1A/R, and will continue to operate in this mode throughout FY 1998. Updates to the multi-increment manifest and the definition of ISS resources available for long range utilization planning will continue, and the IDRD for the year 2000 timeframe will be baselined. A change will be made to the ISS Prime Contract to add sustaining engineering effort through the assembly period plus 12 months. In addition, sustaining engineering activities will develop and implement plans and processes to ensure that all the proper skills, tools, and facilities are in place and ready to support the delivered flight hardware and software in a safe and efficient manner.

FY 1999

In FY 1999, assembly flights increase significantly (2 Russian and 5 U.S.). In addition, the first logistics flight occurs. The following operations activities indicates an intense operations workload: ISS crew simulator training for eight (8)flights: the basic release of the operations data file for seven (7)flights: Shuttle mission integration plans baselined for nine (9)flights; and the basic release of increment specific flight rules for *6* flights. The MCC-H will take over the primary real-time command and control of the ISS in early 1999. Updates to the multi-increment manifest and the definition of **ISS** resources available for long range utilization planning will continue. The IDRD for the year 2001 timeframe will be baselined. Sustaining engineering will continue to support the delivered flight hardware and software while simultaneously maintaining skills, tools, processes, and facilities to ensure that Space Station is operating in a safe and efficient manner.

BASIS OF FY 1999 FUNDING REQUIREMENT

SPACE STATION RESEARCH*

	FY 1997	FY 1998	ET 1999
	(Thousands of Dollars)		
Research Projects.	82,200	95,300	232.200
Utilization Support..	54,600	89,000	140,000
Mir Support (including Mir Research)	59,300	37,000	2,000
Total,	196,100	221.300	374,200

* Research in FY 1997 was funded in both science, aeronautics and technology, and human space flight:

Science, aeronautics and technology	131,400
Research projects	82,200
Utilization support	18,100
Mir support (research)	31,100
Human space flight	64,700
Utilization support	36,500
Mir support	28,200

PROGRAM GOALS

NASA will utilize the International Space Station (ISS) as an interactive laboratory in space to advance fundamental scientific knowledge and to foster new scientific discoveries for the benefit of the United States (U. *S.)* and to accelerate the rate at which it develops beneficial applications derived from long-term, space-based research. The ISS will be the world's premier facility **for** studying the role of gravity on biological, physical and chemical systems. The program will deliver the capability to perform unique, long-duration, space-based research in cell and developmental biology, plant biology, human physiology, biotechnology, fluid physics, combustion science, materials science and fundamental physics. **ISS** also provides a unique platform for making observations **of** the Earth's surface and atmosphere, the sun, and other astronomical objects, as well as the space environment and its effects on new spacecraft technologies.

As NASA moves into the Space Station era, there will be a major transition from the current short-term on-orbit experimentation program to the long-term research efforts made possible by the capabilities of the ISS. The core of the Space Station research program will be eight major research facilities: the Gravitational Biology Facility, the Centrifuge Facility, the Human Research Facility, the Materials Science Research Facility (formerlyknown as the Space Station Furnace Facility), the Biotechnology Facility (which includes Protein Crystal Growth activities), the Fluids and Combustion Facility, the Window Observational Research Facility, and the Low Temperature Microgravity Physics Facility. In addition to the eight major facilities, NASA will develop common-use Laboratory Support Equipment and the Expedite the Processing of Experiments to Space Station (EXPRESS) racks and pallets for the Station.

STRATEGY FOR ACHIEVING GOALS

In 1996 NASA consolidated the management of Space Station research and technology, science utilization, and payload development with the Space Station development and operations program in order to enhance the integrated management of the total content of the ISS budget. The Space Station program manager **is** now responsible for the cost, schedule and technical performance of the total program. The Office of Life and Microgravity Sciences and Applications (OLMSA) and Office of Earth Science remain responsible for establishing the research requirements consistent with the overall Space Station objectives. The FY 1998 budget reflects this consolidation by funding the total budget within the Space Station budget line of the Human Space Flight appropriation account. The research and technology elements of the program, including Mir support and research, and the Station-related Space Product Development activities from the former Office of Space Access and Technology, are included in the Space Station Research budget. In a FY 1997 revised operating plan, the U.S./Russian Cooperative program budget line was discontinued, and Mir Support was transferred to the Space Station program budget line.

The Space Station program completed a major restructuring in order to match research utilization of the on-orbit resources with the research support capabilities during the assembly period, and to enhance science planning and training for long-term operations. Reviews of research facilities, payloads, and user operations against the NASA research objectives were completed in the summer of 1997 to ensure an appropriate strategy was devised to achieve the maximum scientific and technological return. In order to more closely align the delivery of the research facilities to the Station with the availability of crew time, power and upmass capabilities, as well as to address fiscal constraints, several research facilities are now targeted for delivery toward the end of the assembly sequence of the Station. In addition, early research on board the Station during the assembly sequence has been realigned to the available resources.

Significant progress has been made in the establishment of international participation in the provision of U.S. research facilities. The Centrifuge, Centrifuge Accommodation Module, and Life Sciences Glovebox were included in a September 1997 Agreement in Principle with the National Space Development Agency of Japan (NASDA) as partial offset for the Shuttle launch of the JEM. The cryogenic freezer racks and the Minus-Eighty Laboratory Freezer (MELF) for ISS will be provided by the European Space Agency (ESA) under a March 1997 Memorandum of Understanding. The Brazilian Space Agency (AEB), as a participant in the NASA program, will provide the Technology Experiment Facility, Window Observational Research Facility Block 2, and the Expedite the Processing of Experiments to Space Station (EXPRESS) pallet, under an Implementing Arrangement between the U.S. and Brazilian governments.

In the 1998 budget, the Research budget was structured with the following components: Science Utilization, Research Facilities, Utilization Support and Mir Support. In order to more closely mirror the science areas, starting in FY 1998, the Research program is being realigned into the following components: Research Projects (including Advanced Human Support Technology, Biomedical

Research and Countermeasures, Gravitational Biology and Ecology, Microgravity Research, Space Products Development, Earth Observation Systems, and Engineering Technology), Utilization Support (including Flight Multi-User Hardware and Support), and Mir Support (including Mir research).

Prior to the program restructure, Science Utilization supported the development of experiment-unique flight hardware, engineering support to U.S. principal investigators, ground-based facilities, and science operations in the various science disciplines. As a result of the restructure, these activities have been realigned into the various research projects and utilization support, as appropriate.

Research Projects

The primary objective of Advanced Human Support Technology (AHST) is the definition, development and testing of advanced technology hardware and processes in support of humans-in-space engineering and life support, and extra-vehicular activity. Specific areas of potential research which have been identified include closed loop life support systems (CO_2 reduction and O_2 generation), biological water recovery, advanced telemetric biosensors, and wearable computers.

The mission of the AHST research and technology development facility is to identify, develop, and perform flight demonstration, testing, and validation of selected advanced technologies consistent with Space and Life Sciences (SLS) and the NASA Strategic Plan. These flight experiments will demonstrate miniaturization, low power consumption, high reliability, ease of use. and cost effectiveness for technologies which play a role in Life Support, Environmental Monitoring and Control, Biomedical Research and Countermeasures, Crew Health Care, and Extravehicular Activities. The AHST rack will provide a means for taking advanced technologies, which may originate within or outside NASA, to levels of maturity beyond what could be accomplished through ground testing alone. This effort will enable rapid accommodation of advanced technologies into operational systems on the ISS. The initial AHST facility payload on the Station is planned as a single modified EXPRESS rack which will support rotation **of** subrack payload investigations with a typical duration of 90-180 days.

Biomedical Research activities include the following: the Human Research Facility (HRF), the Crew Health Care Subsystem (CHeCS) and the associated payload development. HRF hardware will enable the standardized, systematic collection of data from the Space Station's crew members, which the medical and research community will require in order to assure crew health. Once verified on-orbit, the HRF will also be used to conduct basic and applied human research and technology experiments.

In addition to the biomedical research that will be conducted using the HRF, NASA's biomedical activities aboard the **ISS** will include the suite of hardware necessary to protect crew health. The CHeCS will support medical care requirements for the ISS crew following deployment of the U.S. Laboratory module in 1999. CHeCS hardware will provide inflight capabilities for ambulatory and emergency medical care. It will support monitoring of medically necessary environmental parameters, along with capabilities for counteracting the adverse physiological effects of long-duration space flight. Hardware commonality between CHeCS and the HRF is being evaluated, with the synergy between the two programs resulting in maximum research efficiency and cost savings.

The Gravitational Biology and Ecology activities include the Gravitational Biology Facility (GBF), the Centrifuge Facility, and associated payload development activities, combined to make a complete on-orbit laboratory for biological research. The GBF will design, develop, and conduct the on-orbit verification of Space Station research equipment to support the growth and development of a variety of biological specimens, including animal and plant cells and tissues, embryos, fresh and salt water aquatic organisms, insects, higher plants, and rodents. The GBF will support specimen sampling and storage as well as limited analysis activities. The GBF modular design will accommodate the incremental development of experiment capabilities in a manner consistent with evolving ground and flight science needs of the research community.

The Centrifuge Facility includes two habitat holding systems, a two-and-a-half meter diameter centrifuge rotor, life sciences glovebox, and a service system rack. Under the NASA-NASDA Agreement in Principle, NASDA will potentially provide the centrifuge rotor, life sciences glovebox and the Centrifuge Accommodation Module. A formal implementing arrangement to cover Japans contribution is expected to be concluded in mid- 1998.

Microgravity Research activities include development of the Fluids and Combustion Facility, Material Science Research Facility, Biotechnology Facility, Low-Temperature Microgravity Physics Facility, and payload development.

The Biotechnology Facility (BTF) supports research in the areas of protein crystal growth and cell tissue cultures which include studies on the maintenance and response of mammalian tissue cultures in a microgravity environment. The facility will provide a support structure as well as integration capabilities for individual biotechnology experiment modules. Its modular design will provide the flexibility to accommodate a wide range of experiments in cell culturing and protein crystallization. The facility will accommodate changes in experimental modules and analytical equipment in response to changes in science priorities or technological advances. The BTF will support a large group of academic, industrial and government scientists.

The Fluids and Combustion Facility (FCF) supports research on interfacial phenomena, colloidal systems, multiphase flow and heat transfer, solid-fluid interface dynamics, and condensed matter physics, and definition of the mechanisms involved in various combustion processes in the absence of strong buoyant flows. The FCF is a three rack payload. The Fluids Module Experiment Rack is designed to accommodate several multi-purpose experiment modules that are individually configured with facility-provided and experiment-specific hardware to support each fluids experiment. The Combustion Module houses a combustion chamber that is equipped with ports to allow an array of modular diagnostic systems to view the experiment. The facility core rack will provide common support systems for both the combustion and the fluid payload racks: however, the combustion and fluid racks are being designed to operate as standalone hardware during the Station assembly period.

The development of the Space Station Furnace Facility (SSFF) was reassessed in FY 1997 and resulted in reduced FY 1999 funding requirements. This project has been renamed the Materials Science Research Facility (MSRF) and is being restructured to provide the maximum opportunity for material research early in the Space Station assembly sequence, with the ultimate goal of a mature 3-rack facility by the end of assembly. This project will be used to study underlying principles necessary to predict the relationships of synthesis and processing of materials to their resulting structures and properties. It is anticipated that cooperative efforts with the international science community will assist in the development of some discipline-specific furnace modules for use by the U.S. science community, thus leveraging the hardware development investments undertaken by NASA. A final concept will be completed in FY 1998.

The objective of the Low Temperature Microgravity Physics Facility (LTMPF) is to investigate the fundamental behavior of condensed matter without the complications introduced by gravity. Primary LTMPF research will study the universal properties of matter at phase transitions, and the dynamics of quantum fluids. The LTMPF will be a remotely operated payload package attached to the Japanese exposed facility of the Station, and is expected to improve measurements by a factor of 100 over similar terrestrial tests. This attached payload facility will support two independent research instruments simultaneously (at a temperature between 0 and 4 degrees Kelvin) and provide ***6*** to 8 months of microgravity operation between reservicing and hardware changeout.

NASA's commercial research programs for ISS will take advantage of the new opportunities for space flight operations provided by the ISS, and a distinctly new operating environment. Among other activities, the commercial research programs for the ISS will concentrate on commercial protein crystal growth and plant growth research. The commercial protein crystal growth activities for ISS are underway at the Center for Macromolecular Crystallography, and plant growth research at the Wisconsin Center for Space Automation and Robotics, the Center for Bioserve Space Technologies, and their industrial affiliates.

SAGE III will measure chemical properties of the Earth's atmosphere between troposphere and the mesosphere. A key aspect of this research will investigate effects of aerosols on ozone depletion in the atmosphere. SAGE III **is** a payload attached to the outside of the Station and will be mounted on an ESA-provided precision pointing platform.

The Window Observational Research Facility (WORF) will be located in the **U.S.** Laboratory Module at the zenith- (Earth-)pointing window location. The WORF, which includes a high-quality window and a special rack structure to support optical equipment attachment, will provide a crew work station for research-quality Earth observations of rare and transitory surface and atmospheric phenomena. The first version, the Block 1 WORF, is being developed as a research testbed for early utilization during the Station assembly sequence. A more mature Block 2 version is planned to be provided by the Brazilian Space Agency as a subsequent upgrade.

The International Space Station as an Engineering Center (ISSEC) project will be located at JSC and is planned to maximize the use of the ISS as a unique on-orbit laboratory and to foster partnerships with other U.S. Government, industrial, and academic communities. The ISSEC will identify and define innovative technology concepts, develop these concepts into flight experiments, and perform the necessary laboratory-scale investigations on-board the ISS to validate the physical characteristics advanced by these concepts. The ISSEC program promotes the fast track implementation of these experiments. At the same time, the ISSEC program will obtain proposals for the facilities which can provide the necessary support for one or more experiments to operate without duplication of functions.

Utilization Support

Utilization Support provides the necessary capabilities to integrate and operate payloads of commercial, academic and government researchers on the ISS. These capabilities provide the facilities, systems and personnel to support the ISS user community in efficient and responsive user/payload operations. Support is provided for flight and ground capabilities to ensure efficient and complete end-to-end payload operations. Telescience operations are supported to maintain the highest flexibility for both the user community and NASA at the lowest cost. NASA and International Partner payload operations are integrated to ensure compatible use of ISS resources and to resolve payload requirement conflicts.

Utilization Support provides pre-flight payload engineering integration, verification and checkout support, payload operations integration, payload training, mission planning, real-time operations support, data processing and distribution and launch site support. Services begin with initial definition of the payload for flight and continue throughout onboard ISS operation and return of experiment's data and equipment to the user. Services include documentation of interfaces and verification requirements, training of ground and flight teams, and development and execution of mission plans to meet the needs of the user community. Mission execution activities have been streamlined to allow greater payload operational flexibility.

On the ground, the Payload Operations Integration Center (POIC)/United States Operations Center (USOC),Payload Data Services System (PDSS),and the Payload Planning System (PSS) provide the user community with the tools and resources to access ISS flight payload services and conduct operations from their home laboratories. For those users who do not have access to command and telemetry processing capability at their home location, the USOC provides accommodations for them to conduct their ground-based operations support. Development cost of these systems has been reduced by utilizing generic architecture which supports multiple programs including Space Shuttle, Spacelab, and the Advanced X-Ray Astrophysics Facility (AXAF).

Utilization Support also assists payload developers through the provision of payload checkout and verification tools needed for development and verification of their payloads. Among the systems provided are the Payload Rack Checkout Unit (PRCU).and the Suitcase Test Environment for Payloads (STEP). A Payload Data Library (PDL)will provide a single electronic interface for payload developers to provide the requirements and data necessary for the ISS to integrate and operate their experiments.

In addition to the support provided to U.S. payload developers, NASA's Utilization Support will also provide the necessary integration across all International Partner payload planning and operations to ensure efficient, compatible use of Space Station payload resources.

In addition to the major facility-class payloads, NASA plans to fly smaller, less complex payloads on the ISS which will typically have more focused research objectives and shorter development time cycles and will be easily adapted to a variety of users. An EXPRESS Rack concept has been adopted to drastically shorten user pre-flight payload preparation activities. The EXPRESS rack will enable a simple, streamlined analytical and physical integration process for small payloads by providing standard hardware and software interfaces. The project flight and ground systems were successfully demonstrated on a precursor flight of an EXPRESS rack in FY 1997 on the MSL-1 Spacelab mission. The EXPRESS pallet project provides small attached payloads with a similar streamlined process and hardware and software interfaces. The Brazilian Space Agency is responsible for developing the EXPRESS pallets for NASA.

Laboratory Support Equipment (LSE) is also under development for the Space Station in order to support Life and Microgravity Sciences and other experiments. This equipment includes a digital thermometer, videocamera, passive dosimeter, specimen labeling tools, microscopes, small mass measurement device, pH meter, incubator and refrigerated centrifuge. A cryogenic transport freezer and low-temperature onboard freezers are also being developed to support Station research activities.

Mir Support (including Mir Research)

Prior to the budget restructure, Mir Support funding was comprised of a Human Space Flight (HSF) component and a Science, Aeronautics and Technology (SAT) component. It has been reorganized to include the following components: Phase 1 program office, life sciences, aerospace medicine, microgravity research, and mission management and integration.

The Mir program provides for early research opportunities during Phase 1 by conducting long-duration science aboard the Russian Mir space station, as well as shorter duration science investigations on the Space Shuttle rendezvous missions to Mir. Nine Space Shuttle missions to Mir are planned: seven were completed by the end of FY 1997, and two are planned for FY 1998. The program will be completed in FY 1998. The primary objectives of these flights are to rendezvous and dock with the Mir; perform on-orbit, joint U.S./Russian science and research; perform on-orbit joint operations, which will serve as a platform for future ISS operations: resupply Mir logistics: and rotate the American astronauts on-board Mir.

The Mir research program in the life science discipline supports research investigations in environmental monitoring and countermeasures development and validation aboard the Mir. These investigations emphasize musculoskeletal, cardiovascular, regulatory physiology, and neuroscience research, along with plant biology and other fundamental biology research. The Biorack facility developed by ESA is flying on three of the Space Shuttle flights to the Mir. Biorack researchers investigate the influence of gravity on cellular functions and developmental processes in plant and animal tissues. NASA will also use Mir to perform flight experiments in environmental control, advanced life support systems, and advanced space station crew health care systems. These investigations have reduced technical, schedule, and cost risks associated with the development and operation of the ISS.

The Mir research program in the microgravity discipline seeks to mitigate risk in scientific, technological, logistical, and operational planning for the use of the ISS. Additional goals of the microgravity research on Mir are to characterize the microgravity environment on Mir and to conduct specific U.S. investigations in microgravity research disciplines. Microgravity research has utilized modified Space Shuttle experiment apparatus including the middeck glovebox, flight samples, science operations, and data analysis/procedures in order to allow U.S. investigators to fully maximize the capabilities of the Mir Space Station.

MEASURES OF PERFORMANCE

Research Projects

Centrifuge Rotor and Life Sciences Glovebox Development Contract Plan: Under Review Revised: 2nd Qtr FY 1998	Agreement in Principle signed September 10, 1997. Contracts will be developed and released based on a U.S./NASDA negotiated procurement cycle.
FCF Core System Requirements Definition Review (RDR)	This review establishes full scale development plans required for go ahead for development. Due to project restructuring, an integrated FCF hardware concept review is scheduled for 2nd

Plan: Under Review
Actual: 1st Qtr FY 1997

Qtr FY 1998.

FCF Combustion System Preliminary Design Review (PDR)
Plan: Under review
Revised: 1st Qtr FY 1999

This review establishes the "design-to" baseline and ensures that it meets the project baseline requirements. 10% of the flight drawing should be complete at this stage. An integrated facility hardware concept review is scheduled for 2nd Qtr FY 1998.

SSFF Critical Design Review (CDR)
Plan: Under review
Revised: TBD

This project has been renamed Materials Science Research Facility and is being restructured. A requirements assessment review is schedule for 2nd Qtr FY 1998.

Crew Health Care System (CHeCS) Complete CDR
Plan: 2nd Qtr FY 1997
Actual: 4th Qtr FY 1997

Provides crew health care system hardware included in the health maintenance system, and the countermeasure system required to ensure crew health and safety.

CheCS Complete manufacture and assembly of qualification hardware
Plan: 3rd Qtr FY 1997
Revised: 2nd Qtr FY 1998

Provides crew health care system hardware included in the health maintenance system, and the countermeasure system required to ensure crew health and safety.

HRF System CDR, Rack 1
Plan: 1st Qtr FY 1997
Revised: 2nd Qtr FY 1998

This review verifies the suitability **of** the design in meeting the specified requirements and establishes its "build-to" project baseline. 90% of flight drawings should be complete at this stage.

GBF CDR, Rack 1
Plan: 3rd Qtr FY 1997
Revised: 3rd Qtr FY 1998

This review verifies the suitability of the design in meeting the specified requirements and establishes its "build-to" project baseline. 90% of flight drawings should be complete at this stage.

Utilization Support

LSE begin manufacturing of Cryo Storage Units
Plan: TBD
Revised: 3rd Qtr FY 00

Refrigerator /freezer rephased to Flight 19A (Hab Outfitting Flight) when on-board volume becomes available. Cryo Phase B kick-off is schedule for 1st Qtr FY 1999; Phase C/D begins 2nd Qtr FY 00.

EXPRESS Rack CDR
Plan: 2nd Qtr FY 1997

This review verifies the suitability of the design in meeting the specified requirements and establishes its "built-to" project baseline. 90% of flight drawings should be complete at this

Actual: 1st Qtr FY 1997	stage.
Complete all POIC/USOC and facilities outfitting Plan: 1st Qtr FY 1998 Revised: 3rd Qtr FY 1999	Includes workstation upgrades in payload operations integration center (POIC) and U.S. operations center (USOC) at MSFC. Complete communications outfitting 3rd QTR FY1998, remainder of facilities outfitting 2nd QTR FY 1999 to support UF-1 launch preparation.
EXPRESS Pallet PDR Plan: 2nd Qtr FY 1998 Revised: 3rd Qtr FY 1998	This review establishes the “design-to“baseline and ensures that it meets the project baseline requirements. 10% **of** the flight drawing should be complete at this stage.
Complete initial ISS configuration of POIC/USOC systems Plan: 4th Qtr FY 1998 Revised: 2nd QTR FY 1999	POIC/USOC capabilities to support initial ISS payload operations for Utilization Flights 1 and 2. Capabilities are phased commensurate with availability of ISS flight resources. Revised Plan reflects new UF-1 date in ISS Assemble Sequence Revision C.
Complete UF-1 baseline IDRD Plan: 1st Qtr FY 1998 Revised: 4th Qtr FY1998	The interface definition and requirements document (IDRD) describes the on-orbit resources (volume, power, data, etc.) allocated to all payloads. The IDRD for Planning Period 2 (including flight **7.A.**1) has been given priority and will be baselined in 1/98.
WORF Block 1 Preliminary Requirements Review (PRR) Plan: 2nd Qtr FY 1998	This review establishes the ”design-to”baseline and ensures that it meets the project baseline requirements. 10% of the flight drawing should be complete at this stage.
WORF Block 1 CDR Plan: 4th Qtr FY 1998	This review verifies the suitability of the design in meeting the specified requirements and its “build-to”project baseline. 90% of flight drawings should be complete at this stage.
Start Payload Crew Training Plan: 2nd Qtr 1999	”raining will begin for the first crew operating payloads on UF-1/2.
PDSS Initial Operations Capability Plan: 2nd Qtr 1999	The capability to process Ku-band telemetry data for the UF-1 and UF-2 missions will be delivered.
Communications Link Activation Plan: 1st Qtr 1999	The communication link from the HOSC to the Space Station Control Center (SSCC) will be activated to support payload training and operations.
PPS Build 2 Plan: 3rd Qtr 1999	The payload planning system (PPS) capabilities required to support the UF-1 and UF-2 missions will be delivered.

Mir Support (including Mir Research)

Long Duration Mission (LDM)-3 Plan: Sept. 1996 - Jan. 1997 Actual: Sept. 1996 - Jan. 1997	U.S. astronaut stayed aboard the Mir space Station conducting life sciences and microgravity research.
LDM-4 Plan: January - May 1997 Actual: January - May 1997	U.S. astronaut stayed aboard the Mir space Station conducting life sciences and microgravity research. Performed EVA to install Optical Properties Monitor Experiment on the outside of Mir.
LDM-5 Plan: May - Sept. 1997 Actual: May - Sept 1997	U.S. astronaut stayed aboard the Mir space Station conducting life sciences and microgravity research. Performed EVA to inspect the outside of Mir.
LDM-6 Plan: Sept. 1997 - Jan. 1998 Actual: In progress	U.S. astronaut stays aboard the Mir space Station conducting life sciences and microgravity research. U.S. astronaut performs EVA to retrieve NASA Optical Properties Monitor Experiment.
LDM-7 Plan: January - May 1998	U.S. astronaut stays aboard the Mir space Station conducting life sciences and microgravity research.
NASA/Mir 5, 6, 7 Launches Plan: 2nd Qtr FY 1997 (Mir-5) Actual: January 1997 Plan: 3rd Qtr FY 1997 (Mir-6) Actual: May 1997 Plan: 4th Qtr FY 1997 (Mir-7) Actual: September 1997	Spacehab mission management and integration functions for module Flights 5, 6, 7, 8 and 9 will be performed by Spacehab, Incorporated. Life sciences research on Biorack will investigate cellular functions and developmental processes in plant and animal tissues. Microgravity objectives will be focused on reducing scientific risk and enhancing long duration experiment performance and science utilization in preparation for ISS. A multi-disciplined joint U.S./RSA research program will be conducted on a continuous basis on board Mir during this period, and NASA will have a U.S. astronaut on board Mir throughout the period.
NASA/ Mir-8 Launch Plan: 2nd Qtr FY 1998	Same as above.
NASA/ Mir-9 Launch Plan: 3rd Qtr FY 1998	Same as above.

ACCOMPLISHMENTS AND PLANS

Research Projects

The Human Research Facility (HRF) activities have included modifications to existing flight hardware during FY 1997. New hardware has also been developed as a result of payload re-evaluation and new technology inclusion, but it was determined that no prime contracts for major hardware development were necessary for this activity. HRF has relied upon its in-house contractor for hardware engineering and development support. In FY 1998, there will be a Critical Design Review (CDR) for rack 1 of the HRF, and this rack will be delivered to KSC in FY 1999 to be flown on UF-1.

A Memorandum of Agreement (MOA) was developed during FY 1997 between the JSC Space and Life Sciences Directorate and the ISS Payloads Office which will permit the sharing of hardware and research between the HRF and the Crew Health Care Subsystem (CHeCS). CHeCS will provide for medical care for the ISS crew following deployment of the U.S. Laboratory module in 1999, and will provide operational exercise, countermeasures and environmental monitoring aboard the ISS. As a result of this MOA, which is scheduled to be signed in FY 1998, hardware commonality between CHeCS and the HRF was evaluated, and the efficiency and cost savings of the two programs was maximized.

In FY 1997, the Gravitational Biology and Ecology program proceeded with definition studies of the Gravitational Biology Facility (GBF). This facility underwent a mid-year replan in order to reduce budget requirements, take advantage of new technology, and continue to meet requirements of the user community. This replan was approved by both NASA Headquarters and the ISS Program Office, and development of this facility has resumed. This facility will contain cell culture units (CCUs), plant research units (PRUs), advanced animal habitats, aquatic habitats, egg incubators, and insect habitats. A preliminary design review (PDR) was completed for the habitat holding rack in FY 1997, and a CDR will occur in FY 1998. The GBF cell culture unit will accomplish a PDR in FY 1998.

During FY 1997, an agreement in principal was signed with NASDA to build the Centrifuge Facility (CF) and the Life Sciences Glovebox (LSG). In addition to the NASDA developments, the project will continue work on in-house hardware development and test-bedding at Ames Research Center (ARC). ARC is also proceeding with science requirements definition. The CF project continues to support science studies to evaluate and improve upon hardware designs and configurations. A preliminary requirements review (PRR) will occur in FY 1998 for the LSG and in FY 1999 for the CF.

The Microgravity Research program activities for ISS consist of planning and integration activities, developing operations support procedures, and developing experiment unique research hardware for the ISS. The Microgravity Research program has continued the definition, design, and development of its Space Station facilities to meet its long-term program goal to deploy several multi-user facilities specifically designed for long-duration scientific research missions aboard the ISS. To prepare for microgravity operations on the ISS, work continues to define operational requirements and develop telescience techniques. A redefinition and restructuring of the Space Station Furnace Facility has been conducted during FY 1997, and a redesigned facility designated the Materials Science Research Facility (MSRF) has been proposed. The MSRF design allows greater research flexibility, the incorporation of new furnace technology, and earlier research utilization during the Station assembly sequence. A requirements assessment review for the MSRF will be conducted in FY 1998. The ESA-developed Microgravity Science Glovebox will be shipped to KSC in FY 1999 to be launched in FY 2000.

In FY 1998, the Fluids and Combustion Facility (FCF) will complete a hardware concept review for the integrated facility. The Combustion Integrated Rack will accomplish a PDR in FY 1998 and a CDR in FY 1999. A PDR will also be completed for the Fluid Integrated Rack in FY 1999.

During FY 1998, NASA's commercial research programs for the ISS will continue to concentrate on commercial protein crystal growth, where the intent will be to increase the number of samples that can be processed in a given volume, to monitor and control growth conditions, and to develop a new generation of thermal enclosures for crystal growth. **NASA's** commercial protein crystal growth activities for ISS are underway at the Center for Macromolecular Crystallography. NASA's FY 1998 commercial research programs for ISS will also emphasize plant growth research, where the activities of the Wisconsin Center for Space Automation and Robotics, the Center for Bioserve Space Technologies, and their industrial affiliates will use ISS to develop heartier and more resistant plant products and to attain pharmaceutical advances using plants.

The Stratospheric Gas and Aerosol Experiment (SAGE III) is scheduled for flight in FY 2002 and will take advantage of both solar and lunar occultations to measure aerosol and gaseous constituents of the atmosphere. Instrument subelement fabrication continued throughout FY 1997 with no major problems. As part of the ESA Early Utilization Agreement, ESA has agreed to provide a hexapod pointing platform for SAGE III which will provide the 1 degree of pointing accuracy required by the payload. Delivery of the SAGE III flight instrument is scheduled for the first quarter of FY 1999, for launch on UF-4 in FY 2002.

Utilization Support

In FY 1997, a decision was made to defer full payload operations support capability to the UF-3 time frame consistent with Space Station funding priorities for FY 1998. Requirements for initial operations capability (IOC) in the POIC, PDSS, PPS, and Payload Training Center (PTC) were developed **to** support UF-1 and UF-2. The payload integration and operations processes were negotiated with the International Partners and definition of UF-1 and UF-2 payload specific requirements and plans began. Payload training plans and simulator requirements were defined for the UF-1 and UF-2 payloads, and the first two STEP units were delivered to payload developers.

The payload engineering integration and software integration functions were moved from the Boeing-Huntsville contract to the Boeing Prime contract at JSC in FY 1997 This change was made to improve efficiencies in the integration of payloads to the Space Station vehicle and to ensure the Prime contractor is accountable for the performance of the Space Station including the services and interfaces provided to payloads. This contractual change enabled the completion of the Pressurized Payload Interface Requirements Document (IRD) in FY 1997. The IRD is a critical document for payload hardware development. The Payload Data Library (PDL) initial data set development will be completed in FY 1998. The Payload Rack Checkout Unit (PRCU) development was delayed due to late software delivery from the Space Station vehicle. The first PRCU will now be delivered in FY 1998. Payload integration for UF-1 and UF-2 payloads has begun, including development of preliminary ICDs and Payload Integration Agreements (PIAs) for payloads.

In FY 1998, development of the initial operations capability to support UF-1 and UF-2 by the POIC, PDSS, PDL, PTC and PPS continues. The support communications services for the POIC/PDSS will be put in place, enabling connectivity between the POIC and remote payload investigators. PPS Build 1 test and integration will be completed and flight product development for the UF-1 and UF-2 payload complement will begin. The UF-1 and UF-2 payload unique ICDs and verification plans will be completed and the PIAs will be baselined.

In FY 1999, the Huntsville Operations Support Center (HOSC) will be declared operationally ready to support UF-1 and UF-2 payload operations. Many of the UF-1 and UF-2 flight products will be completed and integrated with the systems operations products. The first payload crew will begin training for the UF-1 and UF-2 mission and the integrated engineering and operational assessments will be performed for the UF-1 and UF-2 payload complements. Development will continue on the final operations capabilities of the PDSS, PPS, and PTC to support the UF-3 mission.

In FY 1997, the MSL Spacelab mission successfully demonstrated operations of science payloads on orbit using EXPRESS rack hardware, software, and command protocols. Fabrication and testing of the first EXPRESS rack to fly on the ISS will begin in FY 1999. The first EXPRESS rack is planned for launch on an assembly flight in early FY 2000. In FY 1999 the first flight racks will be shipped to KSC for the UF-1 flight. A total of 10 "suitcase" EXPRESS rack interface simulators are being fabricated for use by EXPRESS payload developers. The first two simulators were completed in the first quarter of FY 1998. All 10 simulator units will be delivered to payload development sites in FY 1998. EXPRESS Rack trainer units will be completed in the first quarter of FY 1999. These units will be used for procedure development and crew training to support the UF-1 and subsequent flights.

During FY 1997, the design requirements for the EXPRESS pallet were completed and approved at the Systems Requirement Review (SRR). An implementing arrangement was signed in October 1998 to transfer development responsibility for the EXPRESS Pallet to the Brazilian Space Agency. EXPRESS Pallet engineering integration, payload software verification, and on-orbit operations will remain the responsibility of NASA. A Joint Management Plan for pallet development is being prepared and will be complete in the second quarter of FY 1998. A PDR for the pallet is scheduled for the fourth quarter of FY 1998, for a first flight in FY 2002 on UF-4.

The Window Observational Research Facility (WORF) for the U.S. Laboratory module completed Phase A conceptual studies in FY 1997 and conducted a Preliminary Requirements Review (PRR) in the first quarter if FY 1998. The PDR and CDR for WORF are scheduled in FY 1998, with flight hardware delivery in FY 1999 to support the UF-1 Station flight in FY 2000. Installation of the optical quality window glass in the U.S. Laboratory module is scheduled for the third quarter of FY 1998. In October 1998, as part of its arrangement with NASA, the Brazilian Space Agency has committed to provide WORF Block II.

Mir Support (including Mir Research)

In FY 1997, three more Space Shuttle-Mir missions were flown, which included three Spacehab double modules. American astronauts spent 12 months aboard Mir conducting research and gaining more long-duration space flight experience. On the seventh Mir mission (STS-86), an EVA was performed to remove external experiments from the docking module and install the NASA

Optical Properties Monitor experiment. The program continues to use the Mir research program to further study the physiological and behavioral changes that occur during long-duration space flight. The Mir research program in FY 1997 provided U.S. extramural investigators with continuing opportunities to conduct plant and animal investigations, including the second and third Biorack flights.

While staying on board the Mir, U.S. astronauts conducted microgravity, fluid physics and combustion research, and life science experiments. Astronauts have concluded two successful plantings and harvest of dwarf wheat with biomass production far exceeding that of any other comparable experiment with plants in space. Also, the duration of in flight tissue culture experiments has been expanded from 2 weeks to over 3 months, demonstrating the ability to support the growth of normal tissues over a prolonged interval.

The microgravity hardware on Mir includes the glovebox, the microgravity isolation mount (MIM) (in collaboration with Canada), and biotechnology hardware to support protein crystal growth and tissue culture growth. The space acceleration measurement system has continued to collect and record data to characterize the Mir microgravity environment and support the microgravity experiments manifested on Mir.

To take maximum advantage of the NASA/Mir opportunity, Space Shuttle flights to Mir were used to develop new technologies for life support and enhance capabilities for on-orbit environmental monitoring. In the life support area, urine processing, water processing, and atmospheric revitalization hardware flight experiments were conducted. In-house and off-the-shelf designs for water and air quality testing and for crew restraints during medical procedures were also utilized. Four of these life support and environmental systems experiments were launched in FY 1996, with remaining experiments launched in FY 1997.

During FY 1998, two Shuttle flights to Mir will be flown which will include a Spacehab double module and a single module. American astronauts will spend 8 months aboard Mir conducting research. An EVA will be performed to remove the Optical Properties Monitor experiment from the outside of Mir. It is anticipated that the Mir Phase 1 program will be completed with the ninth Shuttle flight to Mir in May 1998. The Life Sciences and Microgravity research programs will continue science investigations aboard Mir through FY 1998. Life Sciences expects to conclude its participation in the Mir research program with a successful suite of research and development results in human physiology and behavior and in animal and plant biology.

US/Russian Cooperative
Program

HUMAN SPACE FLIGHT

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **U.S./RUSSIAN COOPERATION AND PROGRAM ASSURANCE**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
Russian Space Agency contract support	100,000	--	--	HSF 2-1
Russian Program Assurance	200,000	50,000	--	HSF 2-1
Total	300,000	50,000	--	
Distribution of Proeram Amount bv Installation				
Johnson Space Center	297,200	50,000	--	
Kennedy Space Center	2,400	--	--	
Marshall Space Flight Center	300	--	--	
Goddard Space Flight Center	100	--	--	
Total	300,000	50,000	--	

PROGRAM GOALS

In FY 1997, the U.S./Russian Cooperative Program budget line item was discontinued, and a new budget line item entitled, U.S./Russian Cooperation and Program Assurance, was established. This budget line item has two parts, U.S./Russian Cooperation (Russian Space Agency contract support) and Russian Program Assurance (RPA). The RPA budget was established in response to the concerns of the U.S. Government over the impact of the Russian Government's fiscal problems on meeting their commitments. This was highlighted by the slippage of the Russian service module (SM) from May 1998 to December 1998. The U.S. developed a contingency plan and initiated specific developments in the event of further Russian delays or shortfalls. The United States (U.S.) and the Russian Federation have underway a three-phase joint cooperative space program to accomplish five major goals. First, the program permits us to develop, maintain, and enhance capabilities and operations to allow humans to live and work continuously in space. Second, by establishing a relationship with Russia as an international partner for the human exploration and exploration of space, the United States can reduce the cost of future U.S. space initiatives by applying Russian-developed technology. Third, by flying Space Shuttle missions to the Russian Mir, the United States can enhance its understanding of long-duration operations, and gain life sciences and microgravity research benefits from long-duration experimentation. Fourth, and of considerable importance, early cooperation with the Russians permits us to develop common systems and operating procedures which will increase the probability of success and mitigate risks in the design, assembly, and operation of the International Space Station (ISS) in which they are a full partner. Finally, this relationship between the U.S. and Russian space agencies advances U.S. national space programs as well as U.S. aerospace industry.

The RPA provides contingency planning funds to address ISS program requirements resulting from delays on the part of Russia in meeting its commitments to the ISS program. The first step in the contingency plan is to protect against a potential further delay in the SM. The ISS program is purchasing, from the U.S. Naval Research Laboratory (NRL), an interim control module (ICM) to provide attitude control and reboost functions for continuation of the ISS assembly sequence in case the Russian SM is launched later than December 1998. The NRL's ICM will be prepared for a February 1999 launch and will be attached to the back of the Russian-built functional cargo block (FGB). If the SM is launched in December 1998, the ICM will be reconfigured to be attached to the SM. The ICM would then be able to dock to the back of the SM in 1999 to back up any shortfall of Progress fuel resupply vehicles.

STRATEGY FOR ACHIEVING GC

The Russian Space Agency (RSA) contract provides services and hardware for Phase I and selected Phase II activities related to the ISS program. Phase I of the program expands the joint participation by U.S. and Russian crews in Mir and Space Shuttle operations. This expanded program uses the unique capabilities of the Space Shuttle and the Russian Space Station Mir and provides support for nine flights to Mir, including seven long-duration stays of U.S. crew. Phase I provides valuable experience and test data which will greatly reduce technical risks associated with the construction and operation of the ISS and provides early opportunities for extended scientific and research activities. The Russian Space Station's capabilities have been enhanced by contributions from both countries, The Space Shuttle has delivered new Russian-built solar arrays to replace existing arrays on Mir, and one of these new arrays uses solar cells provided by the U.S. Russia has launched the Spektr and Priroda modules to its station, equipped with U.S., Russian, and other international scientific hardware to support science and research experiments. In 1996, NASA exercised options to add an eighth and ninth shuttle flight to Mir. These additional flights will assist Russia in meeting its commitment to deliver key elements used in the early assembly of the ISS and will permit additional NASA astronauts to perform long-duration missions on Mir. The eighth and ninth Mir flights will use the Space Shuttle to reduce a significant logistics shortfall on Mir, conduct vital engineering research and expand our knowledge and experience of the effects of long-duration weightlessness. In addition, these extended Mir operations will assist Russia in its objective to extend the Mir on-orbit lifetime through FY 1999. This approach takes into account the joint U.S./Russian interest in continuation of the Shuttle/Mir program, while minimizing changes to the ISS development plan.

During Phase I, the RSA provides management, Mir lifetime extension, Mir capabilities expansion, docking hardware and mission support for both long-duration and short-term, joint missions. Management activities include project documentation, and program and subcontract management. Mir lifetime extension includes system requirements planning, communication and control systems analyses and upgrades, thermal control documentation and requirements definition, environmentally closed life support system (ECLSS)upgrades, power supply system upgrades, and propulsion systems documentation. To expand Mir capabilities, Spektr and Priroda modules were attached to the Mir for scientific use by Russia and the U.S.

Phase II combines U.S. and Russian hardware to create an advanced orbital research facility with early human-tended capability. This facility will significantly expand the scientific and research activities initiated in Phase I, and will form the core of the ISS. Selected Phase II activities in the contract develop the systems capabilities, support, and other infrastructure to complete the ISS. Under a fixed-price contractual arrangement with NASA, the RSA furnishes supplies and/or services to enhance Mir operational capabilities, perform joint space flights, and conduct joint activities which will assist in the design, development, operations, and utilization of the ISS. During this phase, the RSA also provides management, advanced technology, associated analyses, and ISS elements. ISS elements include: requirements definition of a joint airlock and delivery of androgynous peripheral docking system (APDS)hardware: service module modifications: FGB energy block modifications: delivery of repress/depress pumps for the airlock: and study and documentation related to a scientific power platform.

The RPA program has two primary components. First, modifications are being done to the FGB, an element purchased from Russia and owned by the U.S. The FGB is the first piece of Station hardware to be launched. These modifications enhance the FGB's propulsion control capabilities and make it refuelable. Second, the development of an interim control module (ICM) is being pursued to ensure that sufficient attitude and reboost capability is available if required in the assembly sequence. The ICM is being built by the NRL. The FGB modifications and the ICM addition will enable the on-orbit configuration to be safely maintained even if the Russian service module is delayed for up to *an* additional year beyond the Space Station Control Board baselined launch date of December 1998. Other RPA activities include purchase of docking adapters and SM flight support equipment from RSA, airlock modifications, O^2 compressor for the Airlock, and other related ICM tasks.

<u>MEASURES OF PERFORMANCE</u>

Delivery of passive docking mechanisms Plan: 1st Qtr FY 1996, 3rd Qtr FY 1997 Actual: Jan 1997, July 1997	Delivery of two passive docking mechanisms (Passive 1 and 2), associated avionics, control panels. and documentation to support Phase II Space Shuttle flights to the ISS.
ICM PDR Plan: April 1997 Actual: April 1997	NRL and ISS program office held a preliminary design review (PDR) for the ICM.
Delivery of docking mechanisms Plan: 1st, 2nd, 3rd Qtrs. FY 1998	Delivery of docking mechanisms (APDS # 2, **3,** 4), associated avionics and control panels for ISS/Shuttle.

Deliver APDS # 1 Plan: 3rd Qtr 1997 Actual: Jul 1997	Delivery of docking mechanism (APDS # 1), associated avionics and control panels for ISS/Shuttle
ICM CDR Plan: December 1997 Actual: December 1997	NRL and ISS program office completed the critical design review (CDR) for the ICM
SM Launch Plan: December 1998	The SM will be launched **as** part of the ISS Revision C Assembly Sequence
FDRD Completed Plan: February 2, 1998	Flight design requirements document (FDRD)baseline established in order to allow Shuttle to begin flight design processes
Phase II GSR Plan: March 1, 1998	Phase II ground safety review (GSR) at KSC
Phase II FSR Plan: April 5, 1998	Phase II flight safety review (FSR) at JSC
Cargo Integration Review (CIR) Plan: April 21, 1998	Review of cargo element with Shuttle Program
APAS Delivery Plan: June 30, 1998	Delivery of the androgynous peripheral attachment system (APAS, a docking mechanism) from Energia
Phase III GSR Plan: October 27, 1998	Phase III ground safety review at KSC
Stage Integration Review Plan: November 2, 1998	Stage integration review
Phase III FSR Plan: November **3,** 1998	Phase III flight safety review at JSC
ICM Ship to KSC Plan: December 10, 1998	Begin launch processing, ground operations at KSC

ICM Launch Plan:	February 17, 1999	Planned launch date if Russian service module is delayed

ACCOMPLISHMENTS AND PLANS

RSA contract deliverables paid in FY 1997 were based on a total of 106 achieved milestones. Some of the major activities conducted in FY 1997 included Stage 2 crew training and crew medical support, delivery of ground support equipment, continued implementation of the integrated science plan, delivery of three docking mechanisms, delivery of astronaut consumable supplies, and development and modifications to the service module. During FY 1997, American astronauts were continuously aboard Mir conducting scientific research. Funding for the original $400 million RSA contract under the U.S./Russian cooperative program concluded in FY 1997. However, some milestones, such as delivery of three docking mechanisms, two long duration missions and two Shuttle docking missions to the Mir, will occur in FY 1998.

With the $200 million in FY 1997 funds reallocated from within the Human Space Flight account, funds were sent to **NRL** to begin the development and build of the ICM. A PDR was accomplished in April 1997. FGB performance modifications and work on the 0 2 compressor for the airlock were initiated. **A** modification to the RSA contract was negotiated for the purchase of docking adapters for the ICM.

In FY 1998, **RPA** funding provides for: continuation of FGB performance modifications, airlock modifications, O^2 compressor for the airlock, and production of SM flight support equipment and docking adapters for the ICM. The ICM production will be completed, and the hardware delivered to Kennedy Space Center (KSC). Activities associated with integrating and launching the ICM are: mission operations, engineering, Shuttle, KSC operations, GSFC quality assurance support, MSFC program and technical support, production of wet and dry mockups, and outfitting for crew training.

HUMAN SPACE FLIGHT

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT | **SPACE SHUTTLE**

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
Safety and performance upgrades.	496,000	553,400	571,600	HSF 3-5
Shuttle operations	2.464.900	2,369,400	2,487,400	HSF 3-20
Total..	2.960.900	2.922.800	3,059,000	
Distribution of Program Amount bv Installation				
Johnson Space Center	1,473,600	1,574,500	1,685,800	
Kennedy Space Center	142,900	160,000	227,800	
Marshall Space Flight Center	1,276,500	1,136,400	1,096,200	
Stennis Space Center,	50,500	42,700	40,200	
Dryden Flight Research Center..	5,400	5,600	6,000	
Langley Research Center..	1,000	--	--	
Lewis Research Center	800	--	--	
Goddard Space Flight Center.	500	--	--	
Jet Propulsion Laboratory	2,100	--	--	
Headquarters	7,600	3.600	3,000	
Total..	2,960,900	2.922.800	3,059,000	

GENERAL

The Space Shuttle budget is divided into two categories: Safety and Performance Upgrades (S&PU) and Shuttle Operations. It is distributed to the various program elements through the four Human Space Flight Centers and the Dryden Flight Research Center.

The Space Shuttle program provides launch services to a diversity of customers, supporting payloads that range from small hand-held experiments to large laboratories. While most missions are devoted to NASA-sponsored payloads, wide participation is exercised by industry, partnerships and corporations, academia and other national and international agencies. Both NASA and the U.S. and international scientific communities are beneficiaries of this approach. The Space Shuttle is a domestically and internationally sought-after research facility because of its unique ability to provide on-orbit crew operations, rendezvous/retrieval, and payload provisions, including power, telemetry, pointing and active cooling.

The Space Shuttle services numerous cooperative and reimbursable payloads involving foreign governments and international agencies. The focus of international cooperation, for which the Space Shuttle is uniquely suited, will be the assembly and operational support of the International Space Station (ISS), beginning in FY 1998.

The Space Shuttle program participates in the domestic commercial development of space, providing flight opportunities to NASA's Centers for Commercial Development of Space. These non-profit consortia of industry, academia, and government were created to conduct commercially applied research activities by encouraging industry involvement leading to new products and services through access to the space environment. Over 6 payloads with numerous experiments have been developed through these consortia and were flown in FY 1997. Cooperative activities with the National Institute of Health (NIH), the National Science Foundation (NSF), the Department of Defense and other U.S. agencies are advancing knowledge of health, medicine, science, and technology. Space Shuttle support for the flight of Neurolab in FY 1998, a major cooperative NASA-NIH program, is a prime example.

PROGRAM GOALS

The Space Shuttle program is safely flying more flights at less cost per flight than ever before in the history of the program. The restructuring activities of the past six years have resulted in dollar savings of 31% by FY 1997, equating to 37% **less** workforce since FY 1992. Reliability has improved and since FY 1994, 27 missions have been launched within the first five minutes of the launch window, an 87% success rate. In addition, after 86 successful missions, a significant reduction in operational requirements is continuing. Consolidation of contracts to a single prime contract is progressing successfully since the award of the Space Flight Operations Contract (SFOC) on October 1, 1996. Phase II of the transition is now underway, with the first production hardware contracts (Solid Rocket Booster and External Tank) transferring into SFOC in FY 1998. The total transition is scheduled to be complete by FY 2000.

In FY 1996, the White House, through NASA, commissioned the Aerospace Safety and Advisory Panel (ASAP) to conduct a six-month review to assess if the Space Shuttle program was continuing to operate safely during downsizing activities. On December 13, 1996, the ASAP released their findings that, indeed, efforts to streamline the Space Shuttle Program has not increased risks. The panel did include 22 recommendations, mostly associated with maintaining a skilled, experienced, and motivated workforce especially during International Space Station assembly. To date, all recommendations have been addressed (with one recommendation regarding maintenance of critical skills at KSC, which remains an ongoing, annually-reviewed item).

The Space Shuttle continues to prove itself to be the most versatile launch vehicle ever built. This has been demonstrated by: (1) performing rendezvous missions with the Russian Space Station Mir; (2) advancing life sciences and technology through long-duration Spacelab and Spacehab missions: and *(3)* repairing and servicing the Hubble Space Telescope, enabling discovery of new astronomical events. The Space Shuttle has also performed rescue and retrieval of spacecraft, and is preparing for the challenge of assembly of the International Space Station.

The primary goals of the Space Shuttle program are in priority order: (1) fly safely: (2) meet the flight manifest: *(3)* improve supportability, and (4) reduce costs. The third priority was added in FY 1997 in recognition that the Space Shuttle must be capable of supporting agency launch requirements for the foreseeable future. The "freeze design" decision of the FY 1995 Restructuring Plan was reversed and an upgrade program has been added.

The program's goals are reflected in decisions regarding program requirements, programmatic changes and budget reductions. The flight rate for the program continues to be budgeted at an average of seven flights annually with a surge capability to eight flights. FY 1997 had eight flights, with **six** flights planned for FY 1998. FY 1999 and FY 2000 are eight-flight years with the addition of the Shuttle Radar Topography Mapping (SRTM) Mission, a joint DOD/NASA mission, and two science missions. This manifest supports the Nation's science and technology objectives through scheduled Spacelab, Spacehab and other science missions, cooperative missions to the Russian space station Mir, and commencement of assembly of the International Space Station.

In addition to flying safely, restructuring the program, and conducting a single prime consolidation, we are continuing the Safety and Performance Upgrades program. This includes the completion of selected projects, termed "Phase I" upgrades, that are designed to improve Space Shuttle safety and to improve payload-to-orbit performance by 13,000 pounds. This will allow the Orbiter to achieve the orbital inclination and altitude of the International Space Station and support its assembly beginning in FY 1998. All the Phase I upgrades are on track to meet the performance requirements of the first Space Station assembly flight, STS-88, in the 3rd quarter of FY 1998. "Phase II" upgrades have been added to the program that are required to assure mission supportability into the next century.

Key elements of this budget request are: (1) the continued transition to a single prime contractor for space flight operations: (2) initiation of new Phase II upgrades: and *(3)* Orbital Maintenance Down Periods (OMDPs) to be conducted at Palmdale, California.

In the Space Shuttle's FY 1998 Congressional request, a Phase III/IV portion of the Upgrade Program was envisioned. Since that time, the Agency formed a Space Transportation Council (STC) to assess advanced transportation areas in both the Office of Space Flight and the Office **of** Aeronautics and Space Transportation Technology. Technology need studies were conducted by the Space Shuttle program in FY 1997 and FY 1998. In recognition of the value of close collaboration on the technology needs of future reusable launch vehicles, lead responsibility has been consolidated within the Space Transportation Technology program. The Space Transportation Council will provide management oversight and policy direction across the agency's activities in this area. Potential major Shuttle upgrades will be examined under the Future Space Launch industry-led trade studies described in the Space Transportation Technology section. These studies will provide the basis for end-of-decade decisions by NASA and the Administration on pursuing an operational launch system to reduce **NASA's** launch cost.

STRATEGY FOR ACHIEVING GOALS

The budget structure of the Space Shuttle program consists of two major components: Safety and Performance Upgrades, and Space Shuttle Operations. Safety and Performance Upgrades provide for modifications and improvements to the flight elements and ground facilities, including expansion of safety and operating margins and enhancement **of** Space Shuttle capabilities as well as the replacement of obsolete systems. Shuttle Operations including hardware production, ground processing, launch and landing, mission operations, flight crew operations, training, logistics, and sustaining engineering. In addition, this budget includes funding for facilities related to the Space Shuttle.

The Space Shuttle program's strategy for the Safety and Performance Upgrades budget is to fund those modifications and improvements which will provide for the safe, continuous, and affordable operations of the Space Shuttle system for the foreseeable future. This is an essential element of the launch strategy required for continuing operations supportability of the International Space Station.

The overall strategy for the Shuttle Operations budget is to request funding levels sufficient to allow the Space Flight Operations Contract to meet the intended flight rates, including appropriate contingency planning in both budget and schedule allowances to assure transportation and assembly support to the Space Station program, while at the same time incentivizing the contractor to identify opportunities for reductions in operations costs while still ensuring the safe and reliable operation of the Space Shuttle. The continued transition of activities to the Space Flight Operations Contract represents a key element of this strategy.

BASIS OF FY 1999 FUNDING REQUIREMENT

SAFETY AND PERFORMANCE UPGRADES

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Orbiter improvements	159,900	232,500	234,800
Multifunction-electronic display system	15,900	31,100	5,500
Other orbiter improvements	144.000	201,400	181,300
[Supportability Upgrades] [included above]	[50,000]	[50,000]	48,000
Propulsion upgrades	202.800	176.000	175,700
Space shuttle main engine upgrades	196,000	170,700	172,800
[Alternate Turbopump program]	[79,6001	[72,100]	[63,7001
[Other main engine upgrades]	[116,4001	[98,600]	[109,1001
Solid rocket booster improvements	800	3,500	2,900
Super lightweight tank	6,000	1,800	--
Flight operations & launch site equipment upgrades	125,000	138.100	153.500
Flight operation upgrades	66,400	70.600	38,500
Launch site equipment upgrades	58,600	67,500	115,000
[Supportability Upgrades]	[20,000]	[45,0001	[52,000]
Construction of facilities	8,300	6.800	7.600
Total	496,000	553,400	571,600

GENERAL

The Safety and Performance Upgrade program is measured by the success it has in accomplishing the ongoing projects consistent with approved schedule and cost planning, and also the effect these projects have on the overall operation of the Space Shuttle System. Success depends on developing these projects and getting them implemented to help insure the Space Shuttle's safe operation, and improve the reliability of the supporting elements.

The FY 1999 budget request includes activities in the following categories: Orbiter Improvements, Space Shuttle Main Engine (SSME) Upgrades, Launch Site Equipment (LSE) Upgrades and Flight Operations Upgrades, as well as specific, Space Shuttle-related Construction of Facilities. This budget also includes Supportability upgrades to develop more modern systems which will combat obsolescence of vehicle and ground systems in order to maintain the program's viability into the next century. Vendor loss of aging components, high failure rates of older components, high repair costs of Shuttle-specific devices, and negative environmental impacts of some out-dated technologies are areas to be addressed.

The following is a brief description of these activities.

Orbiter Improvements

The Orbiter improvements program provides for enhancements of the Space Shuttle systems, produces space components that are not susceptible to damage, and maintains core skills and capabilities required to modify and maintain the Orbiter as a safe and effective transportation and science platform. These activities are provided by contract arrangements with Boeing North American (formerly, the Rockwell International Space Division) in two major locations in FY 1998: the Downey, California facility provides engineering, manufacturing and testing: and the Palmdale, California operation provides Orbiter Maintenance Down Period (OMDP) support as discussed below. Other activities that support this effort are subsystem management engineering and analysis conducted by Lockheed-Martin Corporation and development and modifications required for support to the extravehicular capability conducted by Hamilton Standard.

Orbiter Maintenance Down Period (OMDP) occurs when each Orbiter is taken out of service periodically for detailed structural inspections and thorough testing of its systems before returning to operational status. This period also provides opportunities for major modifications and upgrades, especially those upgrades that are necessary for improving performance to meet the International Space Station operational profile.

Propulsion Upgrades

The main engine safety and performance upgrade program is managed by the Marshall Space Flight Center (MSFC) and supports the Orbiter fleet with flight-qualified main engine components and the necessary engineering and manufacturing capability to address any failure or anomaly quickly. The Rocketdyne Division of the Boeing North American Corporation is responsible for operating three locations that provide engine manufacturing, major overhaul, components recycle and test. They are:

(1) Canoga Park, California which manufactures and performs major overhaul to the main engines;
(2) Stennis Space Center (SSC), Mississippi for conducting engine development, acceptance and certification tests; and
(3) Kennedy Space Center (KSC), Florida where the engine inspection checkout activities are accomplished at the KSC engine shop.

Engine ground test and flight data evaluation, hardware anomaly reviews and anomaly resolution are managed by the Marshall Space Flight Center (MSFC). The Alternate Turbopump project is also managed by the MSFC under contract with Pratt Whitney of West Palm Beach, FL. The Super Lightweight Tank project is managed by the MSFC and is being accomplished by the Lockheed Martin Corporation at the government-owned Michoud Assembly Facility **(MAF)** near New Orleans, LA.

Flight Operations and Launch Site Equipment Upgrades

The major flight operations facilities at Johnson Space Center (JSC) include the Mission Control Center (MCC), the flight and ground support training facilities, the flight design systems and the training aircraft fleet that includes the Space Shuttle training aircraft, the T-38 aircraft and the Space Shuttle Carrier Aircraft (SCA). The major launch site operational facilities at KSC include three Orbiter Processing Facilities (OPFs), two launch pads, the Vehicle Assembly Building (VAB), the Launch Control Center (LCC), and three Mobile Launcher Platforms (MLPs). The most significant upgrade in this account is the Checkout and Launch Control System at KSC.

Construction of Facilities

Construction of Facilities (CofF) funding for Space Shuttle projects is provided in this budget to refurbish, modify, reclaim, replace and restore facilities at Office of Space Flight Centers to improve performance, address environmental concerns of the older facilities, and to ensure their readiness to support the Space Shuttle Operations.

PROGRAM GOALS

NASA policy planning assumes the Space Shuttle will need to be capable of supporting the critical transportation requirements for the assembly of the Space Station and perhaps through 10 years of Space Station operations. In order to maintain a viable, human transportation capability that will operate into the next century and support NASA's launch requirements, specific program investments are required. These investments are consistent with NASA's strategy of ensuring the Space Shuttle remains viable until a new transportation system is operational.

STRATEGY FOR ACHIEVING GOALS

This budget provides funds required to modify and improve the capability of the Space Shuttle to ensure its viability as a safe, effective transportation system and scientific platform. It also addresses increasingly stringent environmental requirements, obsolescence of subsystems in the flight vehicle and on the ground, and capital investments needed to achieve reductions in operational costs. Work continues on the Alternate Fuel Turbopump and new Large Throat Main Combustion Chamber (LTMCC) for the planned introduction of the Block II Space Shuttle Main Engine (SSME). Block IIA engines will fly in mid FY 1998 and Block II in early FY 1999.

The major safety and performance upgrades and their initial flight dates are listed on the following chart on the next page.

MEASURES OF PERFORMANCE

The Safety and Performance Upgrade program is measured by the success it has in accomplishing the ongoing projects consistent with approved schedule and cost planning. Success depends on developing/implementing these projects and to heip ensure the

Space Shuttle's safe operation, improve the reliability of the supporting elements, and improving efficiencies to reduce operational costs. This budget addresses all elements of the Space Shuttle program and is managed through an approval process that ensures that new projects are evaluated, approved and initiated on a priority basis, and that existing projects meet established cost and schedule goals. Significant milestones are listed below:

Orbiter Improvements

Multifunction Electronic-Display System (MEDS) - MEDS is a state-of-the-art integrated display system that will replace the current Orbiter cockpit displays with an integrated liquid crystal display system.

Complete MEDS Software Qualification Plan: 1st Qtr FY 1997 Actual: 2nd Qtr FY 1997	Completed MEDS Software development and verification.
Complete MEDS Qualification Testing Plan: 1st Qtr FY 1996 Revised: 1st Qtr FY 1998	Complete hardware qualification testing and start hardware integration and verification testing. The qualification program was extended through this date. **No** significant impact to initial operating capability is expected. Delay was due to change in glass supplier.
OV-104 Major MOD Plan: 2nd Qtr FY 1998 Actual: 2nd Qtr FY 1998	Installation and checkout of MEDS hardware in OV-104 at Palmdale
MEDS Initial Operational Capability (IOC) Plan: 2nd Qtr FY 1999	First flight of a MEDS equipped Orbiter. (OV-104/STS-92)

Global Positioning System (GPS) - GPS will replace the current TACAN navigational system in the Orbiter navigation system when the military TACAN ground stations will be phased out in the year 2000. The planned readiness date for the Space Shuttle's system is FY 1999.

Complete GPS Preliminary Design Review (PDR) Plan: 2nd Qtr FY 1997 Actual: 2nd Qtr FY 1997	Completion of System Requirements Review will allow design drawings to proceed toward Critical Design Review (CDR)
Complete GPS System	Completion **of** CDR will allow drawings to be released for production to proceed.

Requirements Review Plan: 2nd Qtr FY 1997 Actual: 3rd Qtr FY 1997	Delay **is** due to the change from the original, single-string GPS, to the three-string GPS System.
TACAN Removal Plan: 3rd Qtr FY 1998	Remove TACAN at Palmdale based on November 1997 go/no go decision.
Orbiter Install Complete Plan: 4th Qtr FY 1998	Installation and checkout of hardware on OV-104 at Palmdale.
Complete GPS operational capability Plan: 2nd Qtr FY 1999	Initial operation of GPS without TACAN system.

Orbiter Maintenance Down Periods

Initiate Atlantis (OV-104) OMDP Plan: 1st Qtr FY 1998	Conduct routine maintenance and structural inspection. Also install an external airlock, the MEDS upgrade, and hardware for 3-String GPS capability.
Initiate Columbia (OV-102) OMDP Plan: 1st Qtr FY 1999	Conduct routine maintenance and structural inspection. Also, install the MEDS upgrade and hardware for 3-string GPS capability.

Propulsion Upgrades

Super Lightweight Tank - This performance enhancement **is** designed to provide 7,500 pounds of additional performance for the Space Shuttle to allow rendezvous and operations with the International Space Station. Development was completed in FY 1997 with the successful proof test of the first unit.

Design Certification Review Plan: 3rd Qtr FY 1997 Revised: 4th Qtr FY 1997	The Super Lightweight Tank will provide 7,500 pounds of performance through incorporation of an aluminum-lithium alloy in the external tank structure. Schedule revision was due to problems encountered in welding aluminum lithium.
Deliver first SLWT to KSC for flight Plan: 4th Qtr FY 1997 Revised: 2nd Qtr FY 1998	Final assembly and checkout will be conducted at the Michoud Assembly Facility (MAF) in New Orleans, Louisiana. Schedule revision was due to need to perform multiple proof tests to verify welds.

Space Shuttle Main Engine Safety Improvements - Introduction of Block I and Block II changes into the Space Shuttle's Main Engine program will improve the margin of safety by a factor of two. The interim Block IIA configuration (Block I without the High-Pressure Fuel Turbo Pump (HPFTP)) implements the safety and performance margins provided by the LTMCC while the HPFTP development problems are solved. The last Block IIA flight is planned for FY **1999.**

High Pressure Fuel Turbopump Critical Design Review (CDR)	Completion of CDR will allow production to proceed for implementation of the Alternate Turbopump high pressure fuel pump into the Block II Engine upgrade.
Plan: **3rd** Qtr FY **1996**	Revised due to testing delays
Revised: **2nd** Qtr FY **1997**	Opted for IIA configuration because of new HPFTP delays
Revised: **1st** Qtr FY **1998**	Block II status under review at MSFC
Revised: **3rd** Qtr FY **1998**	

First flight of the Block II engine	The high pressure fuel turbopump will be combined with the LTMCC.
Plan: **4th** Qtr FY **1997**	Revised due to testing delays
Revised: **1st** Qtr FY **1998**	Opted for IIA configuration because of HPFTP delays.
Revised: **2nd** Qtr FY **1998**	Block II status under review at MSFC
Revised: **4th** Qtr FY **1998**	

SPACE SHUTTLE PROGRAM SAFETY AND PERFORMANCE ENHANCEMENTS

HEDS STRATEGIC PLAN

Fiscal Year	1995	1996	1997	1998	1999	2000	2001	2002
Alternate Turbopump Development								
-- Oxidizer Turbopump - First Flight	7/95							
-- Fuel Turbopump - First Flight				5/98	NET 12/98			
Large Throat Main Combustion Chamber - First Flight				1/98				
Super Lightweight Tank - First Flight				5/98				
Main Engine Phase II + Powerhead - First Flight	7/95							
Auxilary Power Unit - New Gas Generator Valve - Ready for Flight			7/97					
Multifunction Electronic Display System - First Flight					1/99			

Flight Operations and Launch Site Equipment Upgrades- Upgrades to the Mission Control Center were completed in FY 1997 period which improved operations reliability and maintainability and also took advantage of the state-of-the-art technology in displays and controls. In addition, upgrades continued in FY 1998 to the Launch Site Equipment at KSC will increase reliability and reduce obsolescence.

Deliver first two Portable Purge Units Plan: 3rd Qtr FY 1997 Actual: 3rd Qtr FY 1997	First units delivered and tested by user. Revised due to delay in award of contract.
CLCS Program Authority to Proceed Plan: 1st Qtr FY 1997 Actual: 1st Qtr FY 1997	The Checkout and Launch Control System (CLCS)replace the 1970's Launch Processing System (LPS). Began the formal process of CLCS design and acquisition.
First Launch Using CLCS Plan: 1st Qtr FY 2001	Launch the first Shuttle from a CLCS - equipped Launch Control Center.
Complete Migration of CLCS to all Firing Rooms and Simulators Plan: 4th Qtr FY 2001	CLCS fully operational for flight support. This will result in a significant reduction in operating cost, up to 50%, of the current LPS.

Construction of Facilities

Restore Firex Pumps and Piping at LC-39	Restoration is needed. Pumps are currently inadequate to provide spray coverage during an emergency.
Complete Phase I Plan: 3rd Qtr. FY 97 Actual: 4th Qtr. FY 97	This project replaced underrated firex loop piping and components, and provides fire protection at Pads A and B. Additional work necessary to complete the associated controls including control cable installation and termination on Pad B.
Start Phase II Plan: 2nd Qtr. FY 96 Actual: 2nd Qtr. FY 97	This project removes and replaces existing Firex pumps, motors, refurbishes diesels, and installs a new underground pipe between the pump station and Pads A and B. Completion of this project scheduled for the 3rd Quarter of FY 1999.

Replace Component Refurbishment and Chemical Analysis Facility at KSC	This facility was in non-compliance with OSHA standards and overcrowded and insulated with asbestos.
Complete Phase I Plan: 1st Qtr. FY 97 Actual: 3rd Qtr. FY 97	Completing this effort in FY 1997 is earliest opportunity to comply with requirements during cleaning and degreasing operations.
Complete Phase II Plan: 4th Qtr. FY 97 Revised: 1st Qtr. FY 98	Complete activation of component refurbishment chemical analysis (CRCA)building.
Complete SSME Processing Facility at KSC Plan: 2nd Qtr. FY 98	Project provides for construction of an addition to the east end of the lower level of OPF-3 Annex to provide shop area for SSME processing. The facility will allow for safely and efficiently processing engines.
Rehabilitation of 480V Electrical Distribution System at MAF	External Tank manufacturing building
Start Phase I Plan: 2nd Qtr. FY 97 Actual: 2nd Qtr. FY 97	Phase 1, Final Assembly Area Project will upgrade the power distribution system from below the substation to the respective tools (Labor intensive project working over flight hardware). This phase should be completed by the 2nd Quarter of FY 1999.
Start Phase II Plan: 1st Qtr. FY 98	Phase II, ET Sub-Assembly Area Project will upgrade the power distribution system from below the substation to the respective tools. This phase should be completed in the 1st Quarter of FY 2000.
Start Phase III Plan: 1st Qtr. FY 99	Phase III, Substations 17A/ 17B will replace the core system, transformers, switch gear, breakers and oil switches. Includes some cable, cable tray, and panel upgrades. This phase should be completed in the 1st Quarter of FY 2001.
Complete Pad B Fixed Service Structure (FSS)Elevator at LC-39 Plan: 4th Qtr. FY 97 Actual: 4th Qtr. FY 97	This project replaces the elevator cabs, cables and controls to eliminate severely deteriorated and archaic equipment.

Start Pad B Chiller Replacement at LC-39 Plan: 2nd Qtr. FY 97 Actual: 2nd Qtr. FY 97	This project replaces the aged facility chillers at Launch Complex 39, Pad B, and reconfigures the system for more efficient maintenance. The planned completion date for this project is 2nd Quarter of FY 1999.
Start Rehabilitation of High Pressure Industrial Water System at SSC Plan: 3rd Qtr. FY 97 Actual: 1st Qtr. FY 97	This project initiates the restoration of the High Pressure Industrial Water Plant to insure system reliability in support of the Space Shuttle Main Engine testing. The planned completion date of this project is 2nd Quarter of FY 1999.
Start Restoration of Pad A PCR Wall and Ceiling Integrity at Launch Complex (LC)-39 Plan: 3rd Qtr. FY 98	This project provides for repair and replacement of damaged Payload Change Out Room (PCR)wall panels (Sides 1, 2, 3, & **4),** replacement or elimination of deteriorated and leaking access doors, and other needed replacement and restoration. The modification will eliminate degrading flexducts and filter housings, improve pressurization of the PCR, provide an even distribution of air flow, and provide safe personnel access for maintenance and repair. This project is planned for completion in the 1st Quarter of FY 2000.
Start Pad A Surface and Slope Restoration at LC-39 Plan: 3rd Qtr. FY 98	This project provides for repair of the Pad **A** surface concrete, pad slopes, and the crawlerway grid path. This project is scheduled to be completed in the 1st Quarter of FY 2000.
Start Repair of Pad A Flame Deflector & Trench at LC-39 Plan: 1st Qtr. FY 99	This project provides for repair of the fire resistant surface of the Main and SRB flame deflector, repair/replacement of damaged and corroded structural members, and repair/replacement **of** bricks in the Flame Trench wall. Plan completion date is 1st Quarter FY 2000.
Start Pad A FSS Elevator restoration at LC-39 Plan: 1st Qtr. FY 99	This project modifies the elevator structural on Pad B, and refurbishes the elevator cabs, cables and cableway. Planned completion date is the 1st Quarter of FY 2000.

ACCOMPLISHMENTS AND PLANS

A significant portion of the Safety and Performance Upgrades (S&PU) budget is dedicated to avoiding and preventing deleterious and costly effects of obsolescence, especially at a time when the program is undertaking the challenge of reducing the costs of operations. This portion of the budget contains projects that impact every element of the Space Shuttle vehicle. The S&PU budget will continue to support the replacement of the Orbiters' cockpit displays with Multifunction Electronic Display System (MEDS), replacing Tactical Air Command and Navigation System (TACAN)with Global Positioning System (GPS),upgrading the T-38 aircraft with maintainable systems, replacing elements of the launch site complex, upgrading major elements of the training facilities at Johnson Space Center, testing of main engine components at SSC, testing of Orbiter reaction control systems at the White Sands Test Facility, and replacing critical subsystems in the Kennedy Space Center facility complex.

In addition, this request includes funds for Shuttle Supportability Upgrades which will maintain availability of the Space Shuttle fleet for the foreseeable future.

The Space Shuttle program rationale for supportability upgrades is founded on the premise that safety, reliability, and mission supportability improvements must be made in the Shuttle system to continue to provide safe and affordable operations into the next century. These will enable safe and efficient Shuttle operations during the Space Station era while providing a robust testbed for advanced technologies and a variety of customers.

The Space Shuttle Upgrade activity will be planned and implemented from a system-wide perspective. Individual upgrades will be integrated and prioritized across all flight and ground systems, insuring that the upgrade is compatible with the entire program and other improvements. Selection of new upgrades through the review process approved by the Associate Administrator for Space Flight, the Program Management Council (PMC) and the Administrator will be utilized. Implementation authority and responsibility will be delegated to the Lead Center Director for the Shuttle Program with the Shuttle Program Manager and the projects. Space Shuttle upgrades will be developed and implemented in a phased manner supporting one or more of the following program goals:

- Improve Space Shuttle system safety and/or reliability
- Support the Space Shuttle program manifest/Space Station
- Improve Space Shuttle system support
- Reduce Space Shuttle system operations cost

The phasing strategy will be coordinated with the Reusable Launch Vehicle (RLV) project management, and other development projects, to capture common technology developments, while meeting the Shuttle manifest. This phasing strategy should allow the incorporation of additional, more comprehensive upgrades to the Space Shuttle system while benefiting other programs and technologies. Candidate upgrades in the initial phases will utilize state-of-the-art technology and provide safety/reliability, supportability, and/or cost (improvement) advantages. Candidate designs in the initial phases would maintain the current Shuttle mold lines and system/subsystem interfaces.

Orbiter Improvements

Orbiter improvements provide for modifications and upgrades to ensure compatibility of the Space Shuttle vehicles with the new Space Station operational environment. Orbiter weight reductions have been identified where operating experience or updated requirements allow selected items to be changed without impact to crew safety or mission success. The Orbiter weight will be reduced by changing the exterior thermal protection materials on certain portions of the Orbiter, deleting portions of the Orbital Maneuvering and Reaction Control Systems (OMS/RCS) that are no longer required, changing the material on the "flipper doors" that provide a seal between the Orbiter wing and its control surfaces, and development of lighter weight crew seats for the cockpit.

There were several improvements implemented in the Space Shuttle vehicle in FY 1997. In the Orbiter, fuel cell single cell monitoring system was installed in response to fuel cell problems encountered during STS-83. The new monitoring system was developed and implemented in the first Orbiter in less than four months. Other Orbiter improvements included new Digital Autopilot (DAP) software designed to reduce fuel consumption in orbit, and new launch trajectory software to increase performance margins and enable the deletion of the Bermuda tracking station for communications during launch. The Solid Rocket Booster also received several upgrades designed to reduce the expense of recovering and refurbishing the boosters. Those upgrades include a saltwater activated mechanism to release the parachutes, improvements to the parachutes themselves, and a modification to the aft skirt brackets.

During FY 1997, Endeavor (OV-105) completed its OMDP and has reentered the fleet in time to fly STS-89 in January 1998. In FY 1998, Atlantis (OV-104) will enter OMDP for normal maintenance, structural inspections, and will also be modified for docking with the International Space Station.

The Multifunction Electronic Display System (MEDS) upgrade will replace the current Orbiter cockpit displays which are early 1970's technology. The current displays which provide command and control of the Space Shuttle are "single string" electro-mechanical devices that are experiencing life related failures and are maintenance intensive. Difficulty in obtaining parts, some of which are no longer manufactured, is becoming more prevalent. The MEDS upgrade is a state-of-the-art, multiple redundant liquid crystal display (LCD) system. MEDS will enhance the reliability of the cockpit display system, resolve the parts availability problem, and provide a much more flexible and capable display system for the crew. This upgrade will bring the Orbiter up to current aircraft standards, benefiting the training of new astronauts directly. Secondary benefits of MEDS are reductions in the Orbiter's weight and power consumption. The MEDS upgrade includes the design effort and production of modification kits for the four Orbiter vehicles. New MEDS ground support hardware is also being designed. When procured and installed it will upgrade the appropriate simulators, test equipment, and laboratories. MEDS will be installed in the Orbiters and tested during the planned OMDPs, beginning with the FY 1998 OV-104 OMDP.

Expansion of the effort to replace the Orbiter's TACAN landing navigation system with the Global Positioning System (GPS) began in FY 1995. This expansion will include an increased interaction of the GPS receiver with the Orbiter backup flight software, and outfitting two more Orbiters with a GPS test receiver. A number of development flights will take place with increasing GPS capability while still utilizing TACAN navigation. The first flight of a complete GPS system is planned for 1999.

Propulsion Upgrades

The most complex components of the Space Shuttle Main Engine (SSME) are the high pressure turbopumps. Engine system requirements result in pump discharge pressure levels from 6000 to 8000 psi and turbine inlet temperatures of 2000 Degrees F. In reviewing the most critical items on the SSME that could result in a catastrophic failure, 14 of the top 25 are associated with the turbopumps. The current pumps' dependence on extensive inspection to assure safety of flight have made them difficult to produce and costly to maintain. The Alternate Turbopump Program (ATP) contract with Pratt & Whitney was signed in December 1986 and called for parallel development of both the High Pressure Oxidizer Turbopump (HPOTP) and the High Pressure Fuel Turbopump

(HPFTP)to correct the shortcomings of the existing high pressure turbopumps. This objective is achieved by: utilizing design, analytical, and manufacturing technology not available during development of the original components; application of lessons learned from the original SSME development program: elimination of failure modes from the design; implementation of a build-to-print fabrication and assembly process: and full inspection capability by design. The turbopumps utilize precision castings, reducing the total number of welds in the pumps from 769 to 7. Turbine blades, bearings, and rotor stiffness are all improved through the use of new materials and manufacturing techniques. The SSME upgrades will expand existing safety margins and reduce operational costs.

The SSME Powerhead is the structural backbone of the engine. The Phase 11+ Powerhead will reduce the number of welds, improving producibility and reliability.

The heat exchanger uses the hot turbine discharge gases to convert liquid oxygen in a thin walled coil to gaseous oxygen for pressurization of the external oxygen tank. The current heat exchanger coil has seven welds exposed to the hot gas environment. A small leak in one of these welds would result in catastrophic failure. The new Single Coil Heat Exchanger eliminated all seven critical welds and tripled the wall thickness.

The Large Throat Main Combustion Chamber (LTMCC)development will result in lower pressures and temperatures throughout the engine system thereby increasing the overall Space Shuttle system flight safety and reliability. The wider throat area accommodates additional cooling channels. Consequently, hot gas wall temperatures are significantly reduced increasing chamber life. The LTMCC design also incorporates new fabrication techniques to reduce the number of critical welds and improve the producibility of the chamber. Development on the powerhead, heat exchanger and LTMCC are all being performed under contract with the Rocketdyne division of the Boeing North American Corporation.

The "block" change concept for incorporating changes into the main engine was introduced and baselined during FY 1994. The Phase 11+ Powerhead, the Single Coil Heat Exchanger and the new high pressure oxidizer turbopump comprise Block I. This change was introduced and flown for the first time in July 1995. The Block II is scheduled to be flown in early FY 1999 and consists of the Large Throat Main Combustion Chamber and the alternate high pressure fuel turbopump. The end result of these engine improvements is an increase in the overall engine durability, reliability and safety margin, and producibility. This is consistent with NASA's goals of decreasing failure probability and reducing Space Shuttle costs.

Increased safety margins and launch reliability on the Space Shuttle will also be realized through the implementation of new sensors (temperature, pressure and flow) for use in the SSME. SSME history has shown that the engine is more reliable than the instrumentation system: however, a transducer failure could result in a flight scrub or on-pad abort, failure to detect an engine fault, or an in-flight abort. These sensor upgrades are essential to improving the reliability of the Space Shuttle's launch capability.

The SLWT program is a result of NASA's desire to enhance the payload capability of the Space Shuttle System to support the Space Station Program. In FY 1996, the verification testing of the Aluminum Lithium Test Article (ALTA)was successfully completed. This test demonstrated the capability of the liquid hydrogen barrel section of the SLWT to withstand flight loads with sufficient margin.

The SLWT is due to complete final assembly and proof testing in January 1998 in preparation for delivery to KSC. First flight is planned for May 1998 on STS-91.

Flight Operations and Launch Site Equipment Upgrades

These upgrades support pre-launch and post-launch processing of the four Orbiter fleet. Key enhancements funded in launch site equipment include: replacement hydraulic pumping units that provide power to Orbiter flight systems during ground processing; replacement of 16-year old ground cooling units that support all Orbiter power-on testing: replacement of communications and tracking Ku-band radar test set for the labs in the Orbiter Processing Facility and High Bays that supports rendezvous capability and the missions: communications and instrumentation equipment survivability projects that cover the digital operational intercom system, major portions of KSC's 17-year old radio system, and the operational television system: improvement of the Space Shuttle operations data network that supports interconnectivity between Shuttle facilities and other KSC and off-site networks; replacement storage tanks and vessels for the propellants, pressurants, and gases: an improved hazardous gas detection system: and fiber optic cabling and equipment upgrades.

A new Checkout and Launch Control System (CLCS)was approved for development at KSC in FY 1997. The CLCS will upgrade the Shuttle launch control room systems with state-of-the-art commercial equipment and software in a phased manner to allow the existing flight schedule to be maintained. The CLCS will reduce operations and maintenance costs associated with the launch control room by as much as 50%, and will provide the building blocks to support future vehicle control system requirements. The Juno and Redstone phases of the CLCS were delivered in FY 1997. In these phases the initial integration platform was defined, the engineering platform was installed, and the interface with the math models was established.. The Thor and Atlas phases are scheduled for completion in FY 1998. During these phases, the initial applications for the Orbiter Processing Facility will be developed, the math models will be validated, an interface to the Shuttle Avionics Integration Lab will be established, and hardware testing will be done. The Titan and Scout phases of CLCS are planned for FY 1999 during which Orbiter automated power-up will be developed, peripheral locations will be upgraded, and selected vertical testing will be done. In FY 2000, the Delta and Saturn phases will be accomplished which includes completion of all launch application development, completion of software certification and validation, and a complete integrated flow demonstration. By the end of FY 2000, Operations Control Room-1 will be fully operation, followed by certification in FY 2001. The first Shuttle launch using the CLCS is scheduled for FY 2001 with full implementation to be completed one year later.

The Hardware Interface Modules (HIM), which are electrical command distribution systems that support the launch processing system (LPS)at KSC, are over 25 years old and have experienced an increased failure rate and higher cost of repair over the past several years. The HIM upgrade replaces all chassis and cards with state-of-the-art "off the shelf' hardware to improve system reliability and maintainability. Production and installation should be complete in FY 1999.

A cable plant upgrade at KSC replaces the miles of cables which support a wide variety of Space Shuttle facilities. Many of these cables were installed in the 1960s and are suffering from corrosion and increasing failure rates. Replacement will reduce the potential for disruption to critical Space Shuttle operations as well as have a direct maintenance benefit. This activity will reduce the possibility of launch delays, increase communication system spares availability, and enhance the reliability of data, instrumentation, voice, and video communications. This upgrade will replace the wide-band distribution system and the lead/antimony sheath cables with fiber optics and plastic sheath, gel-filled cable. In addition, many field terminals will be replaced or upgraded. The upgrade should be complete in late FY 1998.

Funds for other activities include implementing required modifications and upgrades on the T-38 aircraft used for space flight readiness training, capability improvements for weather prediction, and enhancements on information handling to improve system monitoring, notably for anomaly tracking.

Construction of Facilities (CoF)

FY 1997 CoF funding was concentrated on KSC, **MAF,** and SSC facilities. At KSC, there were two projects which are both at Launch Complex Pad B - the replacement of Pad B chiller system and the restoration of the Fixed Support Structure Elevator System. Both systems are over 25 years old and are past their economic life expectancy. These systems are part of a critical path for launch criteria assurance. At **MAF,** the rehabilitation and modification of the 480-volt electrical system are necessary to protect critical manufacturing operations in the final assembly and major weld areas for the manufacturing of the External Tank (ET). At SSC, the restoration of the High Pressure Industrial Water Plant included the overhaul of three diesel engines for the deluge water system and two diesel engines for the electrical generation system. These engines drive the water pumps and electrical generators that provide cooling water and reliable power for all three SSME test stands for flight certification and development testing.

FY 1998 CoF will provide for improvements for facilities at KSC and MAF. At **MAF,** this project is phase II of IV to rehabilitate the 480-volt electrical distribution system that is critical to the manufacturing of the external tank. At KSC, one project will be restoring the walls and ceiling that provides a controlled environment to perform pre-flight services of Space Shuttle hardware at Pad A/LC-39 Payload Change-Out Room (PCR). The other project at KSC will restore the concrete surfaces and slope of Pad A/LC-39 structure.

FY 1999 CoF funding will provide for improvements for facilities at KSC and **MAF.** At KSC, there are two projects which are both at Launch Complex Pad A - the restoration of the Fixed Support Structure Elevator System and the repair of the fire resistant surface of the Main and SRB flame deflector, repair/replacement of damaged and corroded structural members, and repair/replacement of bricks in the Flame Trench wall. At **MAF,** there are two projects Phase III of IV for the rehabilitation of the 480-volt electrical distribution system and Repair Cell E Common solution return and lining. For additional details on these projects, please refer to the <u>Mission Support - Construction of Facilities</u> budget.

BASIS OF FY 1999 FUNDING REQUIREMENT

SHUTTLE OPERATIONS

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Orbiter and integration	492,600	502,900	573,400
[Orbiter]	[124,7001	[126,200]	[113,900]
[System integration]	[367,9001	[376,700]	1459,5001
Propulsion	1,124,700	1,061,800	1,093,400
[External tank]	[352,400]	[341,300]	[404,800]
[Space shuttle main engine]	[208,3001	[204,600]	[175,600]
[Reusable solid rocket motor]	[412,800]	[380,400]	[362,700]
[Solid rocket booster]	[151,2001	[135,500]	[150,3001
Mission and launch operations	847,600	804,700	820,600
[Launch and landing operations]	[801,4001	[710,100]	[728,400]
[Mission and crew operations]	146.2001	[94,600]	[92,200]
Total	2,464,900	2,369,400	2,487,400

GENERAL

Space Shuttle operations requirements are met through a combination of funds received from Congressional appropriations and reimbursements received from customers whose payloads are manifested on the Space Shuttle. The reimbursements are applied consistent with the receipt of funds and mission lead times and are subject to revision as changes to the manifest occur. The FY 1998 planned standard service reimbursements total $11.9 million, with $57.4 million (due to the Shuttle Radar Topograpy Mission) in reimbursements assumed for FY 1999, which offset the total budget for the Space Shuttle, and have been assumed in the NASA direct funding requirements identified above for this budget request.

The Space Shuttle operations budget includes sustaining engineering, hardware and software production, logistics, flight and ground operations, and flight crew operations for all elements while continuing to pursue environmentally necessary operations and manufacturing improvements. The single, prime contract is the Space Flight Operations Contract (SFOC) held by United Space Alliance comprising almost one-half of the Operations budget. As development items are completed, additional effort will be transitioned into SFOC.

Orbiter and Integration

The Orbiter project element consists of the following items and activities:

(1) Orbiter logistics: spares for the replenishment of Line Replacement Units (LRUs) and Shop Replacement Units (SRUs) along with the workforce required to support the program:
(2) Production of External Tank (ET) disconnect hardware:
(3) Flight crew equipment processing as well as flight crew equipment spares and maintenance, including hardware to support Space Shuttle extravehicular activity:
(4) Various Orbiter support hardware items such as Pyrotechnic-Initiated Controllers (PICs), NASA Standard Initiators (NSI's), and overhauls and repairs associated with the Remote Manipulator System (RMS); and
(5) The sustaining engineering associated with the Orbiter vehicles.

The major contractors for these Orbiter activities are United Space Alliance for operations: Boeing North American for External Tank disconnects and Orbiter sustaining engineering; and Hamilton Standard and Boeing for flight crew equipment processing.

System integration includes those elements managed by the Space Shuttle Program Office at the Johnson Space Center (JSC) and conducted primarily by United Space Alliance, including payload integration into the Space Shuttle and systems integration of the flight hardware elements through all phases of flight. Payload integration provides for the engineering analysis needed to ensure that various payloads can be assembled and integrated to form a viable and safe cargo for each Space Shuttle mission. Systems integration includes the necessary mechanical, aerodynamic, and avionics engineering tasks to ensure that the launch vehicle can be safely launched, fly a safe ascent trajectory, achieve planned performance, and descend to a safe landing. In addition, funding is provided for multi-program support at JSC.

Propulsion

External Tanks/Super Lightweight Tanks are produced by Lockheed Martin Corporation in the Government-Owned/Contractor-Operated (GOCO) facility near New Orleans, LA. This activity involves the following:

(1) Procurement of materials and components from vendors:
(2) Engineering and manufacturing personnel and necessary environmental manufacturing improvements.
(3) Support personnel and other costs to operate the GOCO facility; and
(4) Sustaining engineering for flight support and anomaly resolution.

The program began delivering Super Lightweight Tanks to KSC in support of the performance enhancement goal required by the Space Station in FY 1998. Only recurring costs associated with the Super Lightweight Tank are included in this account. Non-recurring costs are accounted for in the Safety and performance Upgrades budget. The External Tank contract is scheduled to be transitioned into Phase II SFOC in FY 1999.

The Space Shuttle Main Engine (SSME) operations budget provides for overhaul and repair of main engine components, procurement of main engine spare parts, and main engine flight support and anomaly resolution. In addition, this budget includes funding to the Department of Defense for Defense Contract Management Command (DCMC) support in the quality assurance and inspection of Space Shuttle hardware: and funds for transportation and logistics costs in support of SSME flight operations. Rocketdyne, a division of Boeing North American Corporation, provides the bulk of the engine components for flight as well as sustaining engineering, integration, and processing of the SSME for flight.

The Solid Rocket Booster (SRB) project supports:

(1) Procurement of hardware and materials needed to support the flight schedule;
(2) Work at various locations throughout the country for the repair of flown components:
(3) Workforce at the prime contractor facility for integration of both used and new components into a forward and an aft assembly: and
(4) Sustaining engineering for flight support.

USBI, Inc., **is** the prime contractor on the SRB and conducts SRB retrieval, refurbishment and processing at KSC. USBI completed the process of consolidating their workforce at Kennedy Space Center from Huntsville, Alabama. The SRB contract is the first major element to be transitioned into Phase II of the SFOC Contract in FY **1998.**

The Reusable Solid Rocket Motor (RSRM) project includes:

(1) Purchase of solid rocket propellant and other materials to manufacture motors and nozzle elements.
(2) Workforce to repair and refurbish flown rocket case segments, assemble individual case segments into casting segments and other production operations including shipment to the launch site:
(3) Engineering personnel required for flight support and anomaly resolution: and
(4) New hardware to support the flight schedule required as a result of attrition.

Thiokol of Brigham City, Utah is the prime contractor for this effort.

Mission and Launch Operations

Launch and Landing Operations provides the workforce and materials to process and prepare the Space Shuttle flight hardware elements for launch as they flow through the processing facilities at the Kennedy Space Center (KSC). The primary contractor is United Space Alliance. This category also funds standard processing and preparation of payloads as they are integrated into the Orbiter, as well as procurement of liquid propellants and gases for launch and base support. It also provides for support to landing operations at KSC (primary), Dryden Flight Research Center (back-up) and contingency sites.

Operation of the launch and landing facilities and equipment at KSC involves refurbishing the Orbiter, stacking and mating of the flight hardware elements into a launch vehicle configuration, verifying the launch configuration, and operating the launch processing system prior to lift-off. Launch operations also provides for booster retrieval operations, configuration control, logistics, transportation, inventory management, and other launch support services. This element also provides funds for:

(1) Maintaining and repairing the central data subsystem, which supports Space Shuttle processing as an on-line element of the launch processing system:
(2) Space Shuttle-related data management functions such as work control and test procedures:
(3) Purchase of equipment, supplies and services: and
(4) Operations support functions including propellant processing, life support systems maintenance, railroad maintenance, pressure vessel certification, Space Shuttle landing facility upkeep, range support, and equipment modifications.

Mission and Crew Operations include a wide variety of pre-flight planning, crew training, operations control activities, flight crew operations support, aircraft maintenance and operations, and life sciences operations support. The primary contractor is US Alliance. The planning activities range from the development of operational concepts and techniques to the creation of detailed systems operational procedures and checklists. Tasks include:

(1) Flight planning:
(2) Preparing systems and software handbooks:
(3) Defining flight rules:
(4) Creating detailed crew activity plans and procedures:
(5) Updating network system requirements for each flight:
(6) Contributing to planning for the selection and operation of Space Shuttle payloads: and
(7) Preparation and plans for International Space Station assembly.

Also included are the Mission Control Center (MCC), Integrated Training Facility (ITF), Integrated Planning System (IPS), and the Software Production Facility (SPF). Except for the SPF (Space Shuttle only), these facilities integrate the mission operations requirements for both the Space Shuttle and International Space Station. Flight planning encompasses flight design, flight analysis, and software activities. Both conceptual and operational flight profiles are designed for each flight, and the designers also help to develop crew training simulations and flight techniques. In addition, the flight designers must develop unique, flight-dependent data for each mission. The data are stored in erasable memories located in the Orbiter, ITF Space Shuttle mission simulators, and MCC computer systems. Mission operations funding also provides for the maintenance and operation of critical mission support facilities including the MCC, ITF, IPS and SPF. Finally, Mission and Crew Operations include maintenance and operations of aircraft needed for flight training and crew proficiency requirements. Other support requirements are also provided for in this budget, including engineering tasks at JSC which support flight software development and verification. The software activities include development, formulation, and verification of the guidance, targeting, and navigation systems software in the Orbiter. The Flight Software Contract with Lockheed Martin will transition into the Phase II of the SFOC Contract in FY 1998.

PROGRAM GOALS

The goal of Space Shuttle Operations is to provide safe, reliable, and effective access to space. The flight rate for the program continues to be budgeted at an average of seven flights annually with surge capability to eight flights. Eight flights were flown in FY 1997, and six flights are planned in FY 1998. Eight flights are planned for FY 1999.

STRATEGY FOR ACHIEVING GOALS

The Space Shuttle program is aggressively continuing to reduce the cost of operations. Since FY 1992, cost reduction efforts have been successful in identifying and implementing program efficiencies and specific content reductions. Space Shuttle project offices and contractors have been challenged to meet reduced budget targets.

United Space Alliance (USA) was awarded the Space Flight Operations Contract (SFOC) on October 1, 1996. It includes a phased approach to consolidating operations into a single prime contract for operational activities. The first phase began in late 1996 with 12 operational and facility contracts being consolidated from the majority of the effort previously conducted by Lockheed Martin and Boeing North American (the two corporations which comprise the US Alliance joint venture). The second phase will add other operations work to the contract after the contractor has had an appropriate amount of time to evolve into its more responsible role in phase I. Transition will take another **1-2** years and employ approximately 7300 equivalent persons at steady state. All transitions will be completed in FY 2000. The reasons for this phased approach are two-fold:

1. The ongoing major development projects (e.g. SLWT, MEDS, ATP, etc.) will be completed.
2. The transition to the prime can occur at a more measured pace.

The roles and missions of the contractor and government relationships have been defined to insure program priorities are maintained and goals are achieved. The SFOC contractor is responsible for flight, ground, and mission operations of the Space Shuttle. The accountability **of** its actions and those of its subcontractors will be evaluated and incentivized through the use of a combined award/incentive fee structure of the performance-based contract. NASA as owner of assets, customer of operations services, and director of launch/flight operation, is responsible for (a) surveillance and audit to ensure compliance with SFOC requirements, and (b) internal NASA functions. Further, NASA retains chairmanship of control boards and forums responsible for acceptance/rejection/waiver of Government requirements while the SFOC contractor is responsible for requirement implementation. The SFOC contractor is required to document and maintain process/controls necessary to ensure compliance with contract requirements and to sign a certification of flight readiness (CoFR) to that effect for each flight..

MEASI OF PERFORMANCE

Since the Space Shuttle program has both an operational and development component, performance measures related to the Space Shuttle program reflect a number of different activities ranging from missions planned and time on-orbit in Shuttle Operations, to development milestones planned for the Safety and Performance Upgrades program. The following sets of diverse metrics can be utilized to assess overall program performance.

Operations Metrics	FY 1997 Revised plan	FY 1997 Actual	FY 1998 plan	FY 1998 Current	FY 1999 Plan
Number of Space Shuttle Flights*	7	8	7	6	8
Shuttle Operations Workforce (Prime Contractor (equivalent personnel))	16.519	16,519	16,478	16,023	15,550
Space Shuttle Processing Overtime Required	3%	3%	3%	3%	3%
Number of Days On-orbit	90	94	76	68	90
Number of Primary Payloads Flown	9	10	8	8	9

* Mission added for MSL-1 Reflight (STS-94).

Space Shuttle Missions and Primary Payloads

FY 1997		Plan	Actual
STS-80/Columbia	Wake Shield Facility-3 (WSF-3)/OREFUS-SPAS-02	November 1996	November 1996
STS-81/Atlantis	Russian Space Station Mir (Mir-5)/Spacehab	December 1996	January 1997
STS-82/Discovery	Hubble Space Telescope Servicing Mission (MSTSM-02)	February 1997	February 1997
STS-83/Columbia	Microgravity Science Laboratory (MSL-1)	March 1997	April 1997
STS-84/Atlantis	Russian Space Station Mir (Mir-6)/Spacehab	May 1997	May 1997
STS-94/Columbia	MSL Reflight	--	July 1997
STS-85/Discovery	Japan Manipulator Flight Demonstration/CRISTA-SPAS-02	July 1997	August 1997
STS-86/Atlantis	Space Station Mir (Mir-7)	September 1997	September 1997

FY 1998		Plan	
STS-87/Columbia	Microgravity Payload (USMP-04)/Spartan 201-04	November 1997	November 1997
STS-89/Endeavour	Russian Space Station Mir (Mir-8)/Spacehab	January 1998	
STS-90/Columbia	Neurolab	April 1998	
STS-91/Discovery	Russian Space Station Mir (Mir-9)/Spacehab	May 1998	
STS-88/Endeavour	Space Station #1 (Node 1)(ISS-01-2A)	July 1998	
STS-93/Columbia	AXAF (under review)	August 1998	

FY 1999		Plan
STS-95/Discovery	Hubble Orbital System Test (HOST)/Spacehab	October 1998
STS-96/Endeavour	Space Station #2 Spacehab Cargo Module (ISS-02-2A.1)	December 1998
STS-92/Atlantis	Space Station #3 (ITS-21)(ISS-03-3A)	January 1999
STS-97/Discovery	Space Station #4 (PV Module) (ISS-04-4A)	April 1999
STS-98/Endeavour	Space Station #5 (US Lab) (ISS-05-5A)	May 1999
STS-99/Atlantis	Space Station #6 (MPLM) (ISS-06-6A)	June 1999
STS-100/Discovery	Space Station #7 (Airlock (ISS-07-7A)	August 1999
STS-101/Endeavour	Shuttle Radar Topography Mission (SRTM)	September 1999

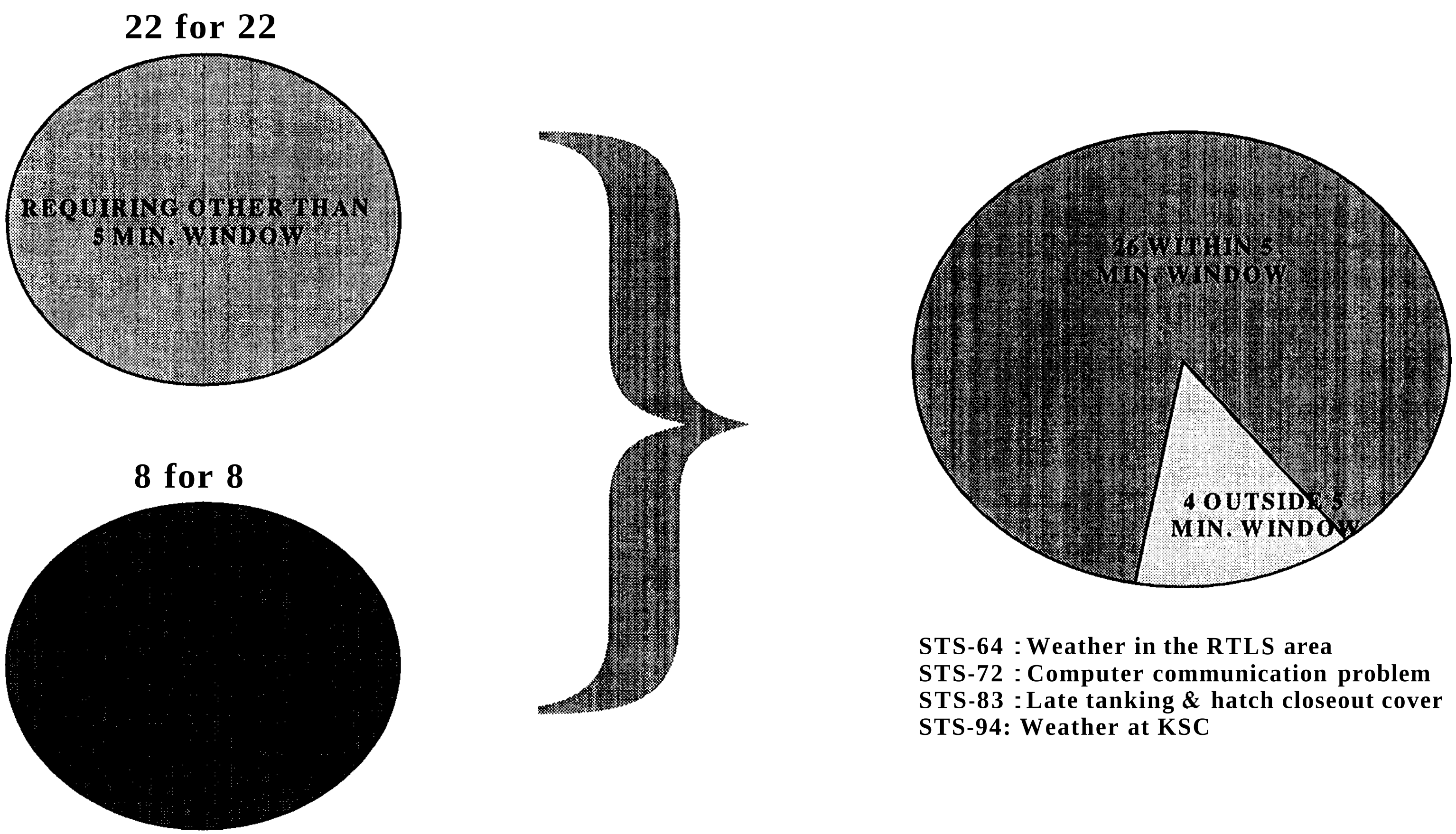
The Space Shuttle program currently provides launch support for space science missions accommodating universities and industry as a space laboratory and technology research vehicle. Beginning in FY 1998, its primary mission will be to support the on-orbit assembly and operations of the International Space Station. The Shuttle is also the only U.S. vehicle that provides human transportation to and from orbit. In FY 1997, 52 crew members flew approximately 818 days, including time spent by an American astronaut aboard Mir. In FY 1998, 37 crew members are planned to fly approximately 669 days, including time spent by American astronaut aboard Mir. This will be followed by approximately 60 crew members flying 810 crew days in FY 1999, including time spent by Americans aboard the International Space Station.

To supplement the network of management reviews and government oversight functions, **NASA** continues to seek specific objective measurements of overall performance of the Space Shuttle program. In order to permit rapid review by the program managers, the Shuttle program has devised a series of "stoplight" metrics. The metrics are devised whereby certain program aspects are measured against established limits or program parameters and then translated into the appropriate green, yellow or red indicators. Among the metrics displayed in this manner are in-flight anomalies, monthly cost rate, Shuttle processing monthly mishaps, Orbiter systems and line replaceable unit (LRU) problem reports, Shuttle processing contract overtime percentage, and KSC quality surveillance error rate. The Shuttle program also tracks its launch history, monitoring the number of liftoff attempts per mission, and characterizing any delays or scrubs as to technical, weather or operational-related reasons.

SHUTTLE LAUNCH HISTORY

30 for 30 LAUNCHES MEETING OUR COMMITMENT

(STS-61 thru STS-87)



STS-64 : Weather in the RTLS area
STS-72 : Computer communication problem
STS-83 : Late tanking & hatch closeout cover
STS-94: Weather at KSC

11/19/97

ACCOMPLISHMENTS AND PLANS

In FY 1997, the Space Shuttle launched eight flights successfully including three flights to the Russian Mir Space Station. Additional flights deployed the Wake Shield Facility (WSF-3) and OREFUS-SPAS-02; and the Japan Manipulator Flight Demonstration as well as CRISTA-SPAS-02 pallet mission. The second Hubble Space Telescope Servicing Mission was conducted, and the Microgravity Science Laboratory (MSL) was flown twice.

The six flights manifested for FY 1998 include a major microgravity payload, the last Spacelab mission (Neurolab), and two more resupply flights to the Russian Space Station Mir. The Space Shuttle will also make its first assembly flight to the International Space Station. Finally the Space Shuttle plans to deploy the last of the "Great Observatories" when it launches the Advanced X-Ray Astrophysics Facility (AXAF).

Eight flights will be flown during FY 1999, including six International Space Station assembly flights. In addition, the last two dedicated research missions will be flown: one on Spacehab, and the Shuttle Radar Topography Mission (SRTM), a joint DOD/NASA payload to study the earth.

US/Russian Cooperative
Program

HUMAN SPACE FLIGHT

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE ,IGH **U.S./RUSSIAN COOPERATION AND PROGRAM ASSURANCE**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
Russian Space Agency contract support	100,000	--	--	HSF 2-1
Russian Program Assurance..	200,000	50,000	--	HSF 2-1
Total..	300,000	50,000	--	

Distribution of Program Amount by Installation

	FY 1997	FY 1998	FY 1999
Johnson Space Center	297,200	50,000	--
Kennedy Space Center	2,400	--	--
Marshall Space Flight Center	300	--	--
Goddard Space Flight Center...	100	--	--
Total..	300,000	50,000	--

PROGRAM GOALS

In FY 1997, the U.S./Russian Cooperative Program budget line item was discontinued, and a new budget line item entitled, U.S./Russian Cooperation and Program Assurance, was established. This budget line item has two parts, U.S./Russian Cooperation (Russian Space Agency contract support) and Russian Program Assurance (RPA). The RPA budget was established in response to the concerns of the U.S. Government over the impact of the Russian Government's fiscal problems on meeting their commitments. This was highlighted by the slippage of the Russian service module (SM) from May 1998 to December 1998. The U.S. developed a contingency plan and initiated specific developments in the event of further Russian delays or shortfalls. The United States (U.S.) and the Russian Federation have underway a three-phase joint cooperative space program to accomplish five major goals. First, the program permits us to develop, maintain, and enhance capabilities arid operations to allow humans to live and work continuously in space. Second, by establishing a relationship with Russia as an international partner for the human exploration and exploration of space, the United States can reduce the cost of future U.S. space initiatives by applying Russian-developed technology. Third, by flying Space Shuttle missions to the Russian Mir, the United States can enhance its understanding of long-duration operations, and gain life sciences and microgravity research benefits from long-duration experimentation. Fourth, and of considerable importance. early cooperation with the Russians permits us to develop common systems and operating procedures which will increase the probability of success and mitigate risks in the design, assembly, and operation of the International Space Station (ISS) in which they are a full partner. Finally, this relationship between the U.S. and Russian space agencies advances U.S. national space programs as well as U.S. aerospace industry.

The RPA provides contingency planning funds to address ISS program requirements resulting from delays on the part of Russia in meeting its coniniitments to the ISS program. The first step in the contingency plan is to protect against a potential further delay in the SM. The ISS program is purchasing, from the U.S. Naval Research Laboratory (NRL), an interim control module (ICM) to provide attitude control and reboost functions for continuation of the ISS assenibly sequence in case the Russian SM is launched later than December 1998. The NRL's ICM will be prepared for a February 1999 launch and will be attached to the back of the Russian-built functional cargo block (FGB). If the SM is launched in December 1998, the ICM will be reconfigured to be attached to the SM. The ICM would then be able to dock to the back of the SM in 1999 to back up any shortfall of Progress fuel resupply vehicles.

STRATEGY FOR ACHIEVING GOALS

The Russian Space Agency (RSA)contract provides services and hardware for Phase I and selected Phase II activities related to the ISS program. Phase 1 of the program expands the joint participation by U.S. and Russian crews in Mir and Space Shuttle operations. This expanded program uses the unique capabilities of the Space Shuttle and the Russian Space Station Mir and provides support for nine flights to Mir, including seven long-duration stays of U.S. crew. Phase I provides valuable experience and test data which will greatly reduce technical risks associated with the construction and operation of the ISS and provides early opportunities for extended scientific and research activities. The Russian Space Station's capabilities have been enhanced by contributions from both countries. The Space Shuttle has delivered new Russian-built solar arrays to replace existing arrays on Mir, and one of these new arrays uses solar cells provided by the U.S. Russia has launched the Spektr and Priroda modules to its station, equipped with U.S., Russian, and other international scientific hardware to support science and research experiments. In 1996, NASA exercised options to add an eighth and ninth shuttle flight lo Mir. These additional flights will assist Russia in meeting its commitment to deliver key elements used in the early assembly of the ISS and will permit additional NASA astronauts to perform long-duration missions on Mir. The eighth and ninth Mir flights will use the Space Shuttle to reduce a significant logistics shortfall on Mir, conduct vital engineering research and expand our knowledge and experience of the effects of long-duration weightlessness. In addition, these extended Mir operations will assist Russia in its objective to extend the Mir on-orbit lifetime through FY 1999. This approach takes into account the joint U.S./Russian interest in continuation of the Shuttle/Mir program, while minimizing changes to the ISS development plan.

During Phase I, the RSA provides management, Mir lifetime extension, Mir capabilities expansion, docking hardware and mission support for both long-duration and short-term, joint missions. Management activities include project documentation, arid program and subcontract management. Mir lifetime extension includes system requirements planning, communication and control systems analyses and upgrades, thermal control documentation and requirements definition, environmentally closed life support system (ECLSS) upgrades, power supply system upgrades, and propulsion systems documentation. To expand Mir capabilities, Spektr and Priroda modules were attached to the Mir for scientific use by Russia and the U.S.

Phase II combines U.S. and Russian hardware to create an advanced orbital research facility with early human-tended capability. This facility will significantly expand the scientific and research activities initiated in Phase I, and will form the core of the ISS. Selected Phase II activities in the contract develop the systems capabilities, support, and other infrastructure to complete the ISS. Under a fixed-price contractual arrangement with NASA, the RSA furnishes supplies and/or services to enhance Mir operational capabilities, perform joint space flights, and conduct joint activities which will assist in the design, development, operations, and utilization of the ISS. During this phase, the RSA also provides management, advanced technology, associated analyses, and ISS elements. ISS elements include: requirements definition of a joint airlock and delivery of androgynous peripheral docking system (APDS) hardware: service module modifications: FGB energy block modifications; delivery of repress/depress pumps for the airlock; and study and documentation related to a scientific power platform.

The RPA program has two primary components. First, modifications are being done to the FGB, an element purchased from Russia and owned by the U.S. The FGB is the first piece of Station hardware to be launched. These modifications enhance the FGB's propulsion control capabilities and make it refuelable. Second, the development of an interim control module (ICM) is being pursued to ensure that sufficient attitude and reboost capability is available if required in the assembly sequence. The ICM is being built by the NRL. The FGB modifications and the ICM addition will enable the on-orbit configuration to be safely maintained even if the Russian service module is delayed for up to an additional year beyond the Space Station Control Board baselined launch date of December 1998. Other RPA activities include purchase of docking adapters and SM flight support equipment from RSA, airlock modifications, O^2 compressor for the Airlock, and other related ICM tasks.

IRES OF CE

Delivery of passive docking mechanisms Plan: 1”‘Qtr FY 1996, 3rd Qtr FY 1997 Actual: Jan 1997 July 1997	Delivery of two passive docking mechanisms (Passive 1 and 2), associated avionics, control panels, and documentation to support Phase II Space Shuttle flights to the ISS.
ICM PDR Plan: April 1997 Actual: April 1997	NRL and ISS program office held a preliminary design review (PDR) for the ICM.
Delivery of docking mechanisms Plan: 1st, 2nd, 3rd Qtrs. FY 1998	Delivery of docking mechanisms (APDS # 2, 3, 4), associated avionics and control panels for ISS/Shuttle.

Deliver APDS # 1 Plan: 3rd Qtr 1997 Actual: Jul 1997	Delivery of docking mechanism (APDS # 1), associated avionics and control panels for ISS/Shuttle
ICM CDR Plan: December 1997 Actual: December 1997	NRL and ISS program office completed the critical design review (CDR) for the ICM
SM Launch Plan: December 1998	The SM will be launched as part of the ISS Revision C Assembly Sequence
FDRD Completed Plan: February 2, 1998	Flight design requirements document (FDRD)baseline established in order to allow Shuttle to begin flight design processes
Phase II GSR Plan: March 1, 1998	Phase II ground safety review (GSR) at KSC
Phase II FSR Plan: April 5, 1998	Phase II flight safety review (FSR) at JSC
Cargo Integration Review (CIR) Plan: April 21, 1998	Review of cargo element with Shuttle Program
APAS Delivery Plan: June **30,** 1998	Delivery of the androgynous peripheral attachment system (APAS, a docking mechanism) from Energia
Phase III GSR Plan: October 27, 1998	Phase III ground safety review at KSC
Stage Integration Review Plan: November 2, 1998	Stage integration review
Phase III FSR Plan: November 3, 1998	Phase III flight safety review at JSC
ICM Ship to KSC Plan: December 10, 1998	Begin launch processing, ground operations at KSC

ICM Launch Plan: February 17, 1999 — Planned launch date if Russian service module is delayed

ACCOMPLISHMENTS AND PLANS

RSA contract deliverables paid in FY 1997 were based on a total of 106 achieved milestones. Some of the major activities conducted in FY 1997 included Stage 2 crew training and crew medical support, delivery of ground support equipment, continued implementation of the integrated science plan, delivery of three docking mechanisms, delivery of astronaut consumable supplies, and development and modifications to the service module. During FY 1997, American astronauts were continuously aboard Mir conducting scientific research. Funding for the original $400 million RSA contract under the U.S./Russian cooperative program concluded in FY 1997. However, some milestones, such as delivery of three docking mechanisms, two long duration missions and two Shuttle docking missions to the Mir, will occur in FY 1998.

With the $200 million in FY 1997 funds reallocated from within the Human Space Flight account, funds were sent to NRL to begin the development and build of the ICM. A PDR was accomplished in April 1997. FGB performance modifications and work on the 0 2 compressor for the airlock were initiated. A modification to the RSA contract was negotiated for the purchase of docking adapters for the ICM.

In FY 1998, RPA funding provides for: continuation of FGB performance modifications, airlock modifications, O' compressor for the airlock, and production of SM flight support equipment and docking adapters for the ICM. The ICM production will be completed, and the hardware delivered to Kennedy Space Center (KSC). Activities associated with integrating and launching the ICM are: mission operations, engineering, Shuttle, KSC operations, GSFC quality assurance support, MSFC program and technical support, production of wet and dry mockups, and outfitting for crew training.

HUMAN SPACE FLIGHT

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **SPACE SHUTTLE**

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
Safety and performance upgrades	496,000	553,400	571,600	HSF 3-5
Shuttle operations	2.464.900	2.369.400	2,487,400	HSF 3-20
Total	2.960.900	2.922.800	3,059,000	
Distribution of Program Amount bv Installation				
,Johnson Space Center	1,473,600	1,574,500	1,685,800	
Kennedy Space Center	142,900	160,000	227,800	
Marshall Space Flight Center	1,276,500	1,136,400	1,096,200	
Stennis Space Center	50,500	42,700	40,200	
Dryden Flight Research Center	5,400	5,600	6,000	
Langley Research Center	1,000	--	--	
Lewis Research Center	800	--	--	
Goddard Space Flight Center	500	--	--	
Jet Propulsion Laboratoiy	2,100	--	--	
Headquarters	7,600	3.600	3,000	
Total	2.960.900	2,922,800	3.059.000	

GENERAL

The Space Shuttle budget is divided into two categories: Safety and Performance Upgrades (S&PU) and Shuttle Operations. It is distributed to the various program elements through the four Human Space Flight Centers and the Dryden Flight Research Center.

The Space Shuttle program provides launch services to a diversity of customers, supporting payloads that range from small hand-held experiments to large laboratories. While most missions are devoted to NASA-sponsored payloads, wide participation is exercised by industry, partnerships and corporations, academia and other national and international agencies. Both NASA and the U.S. and international scientific communities are beneficiaries of this approach. The Space Shuttle is a domestically and internationally sought-after research facility because of its unique ability to provide on-orbit crew operations, rendezvous/retrieval, and payload provisions, including power, telemetry, pointing and active cooling.

The Space Shuttle services numerous cooperative and reimbursable payloads involving foreign governments and international agencies. The focus of international cooperation, for which the Space Shuttle is uniquely suited, will be the assembly and operational support of the International Space Station (ISS), beginning in FY 1998.

The Space Shuttle program participates in the domestic commercial development of space, providing flight opportunities to NASA's Centers for Commercial Development of Space. These non-profit consortia of industry, academia, and government were created to conduct commercially applied research activities by encouraging industry involvement leading to new products and services through access to the space environment. Over 6 payloads with numerous experiments have been developed through these consortia and were flown in FY 1997. Cooperative activities with the National Institute of Health (NIH), the National Science Foundation (NSF), the Department of Defense and other U.S. agencies are advancing knowledge of health, medicine, science, and technology. Space Shuttle support for the flight of Neurolab in FY 1998, a major cooperative NASA-NIH program, is a prime example.

PROGRAM GOALS

The Space Shuttle program is safely flying more flights at less cost per flight than ever before in the history of the program. The restructuring activities of the past six years have resulted in dollar savings of 31% by FY 1997, equating to 37% less workforce since FY 1992. Reliability has improved and since FY 1994, 27 missions have been launched within the first five minutes of the launch window, an 87% success rate. In addition, after 86 successful missions, a significant reduction in operational requirements is continuing. Consolidation of contracts to a single prime contract is progressing successfully since the award of the Space Flight Operations Contract (SFOC) on October 1, 1996. Phase II of the transition is now underway, with the first production hardware contracts (Solid Rocket Booster and External Tank) transferring into SFOC in FY 1998. The total transition is scheduled to be complete by FY 2000.

In FY 1996, the White House, through NASA, commissioned the Aerospace Safety and Advisory Panel (ASAP) to conduct a six-month review to assess if the Space Shuttle program was continuing to operate safely during downsizing activities. On December 13, 1996, the ASAP released their findings that, indeed, efforts to streamline the Space Shuttle Program has not increased risks. The panel did include 22 recommendations, mostly associated with maintaining a skilled, experienced, and motivated workforce especially during International Space Station assembly. To date, all recommendations have been addressed (with one recommendation regarding maintenance of critical skills at KSC, which remains an ongoing, annually-reviewed item).

The Space Shuttle continues to prove itself to be the most versatile launch vehicle ever built. This has been demonstrated by: (1) performing rendezvous missions with the Russian Space Station Mir; (2) advancing life sciences and technology through long-duration Spacelab and Spacehab missions: and (3) repairing and servicing the Hubble Space Telescope, enabling discovery of new astronomical events. The Space Shuttle has also performed rescue and retrieval of spacecraft, and is preparing for the challenge of assembly of the International Space Station.

The primary goals of the Space Shuttle program are in priority order: (1) fly safely: (2) meet the flight manifest: *(3)* improve supportability, and (4) reduce costs. The third priority was added in FY 1997 in recognition that the Space Shuttle must be capable of supporting agency launch requirements for the foreseeable future. The "freeze design" decision of the FY 1995 Restructuring Plan was reversed and an upgrade program has been added.

The program's goals are reflected in decisions regarding program requirements, programmatic changes and budget reductions. The flight rate for the program continues to be budgeted at an average of seven flights annually with a surge capability to eight flights. FY 1997 had eight flights, with six flights planned for FY 1998. FY 1999 and FY 2000 are eight-flight years with the addition of the Shuttle Radar Topography Mapping (SRTM) Mission, a joint DOD/NASA mission, and two science missions. This manifest supports the Nation's science and technology objectives through scheduled Spacelab, Spacehab and other science missions, cooperative missions to the Kussian space station Mir, and commencement of assembly of the International Space Station.

In addition to flying safely, restructuring the program, and conducting a single prime consolidation, we are continuing the Safety and Performance Upgrades program. This includes the completion of selected projects, termed "Phase I" upgrades, that are designed to improve Space Shuttle safety and to improve payload-to-orbit performance by 13,000 pounds. This will allow the Orbiter to achieve the orbital inclination and altitude of the International Space Station and support its assembly beginning in FY 1998. All the Phase I upgrades are on track to meet the performance requirements of the first Space Station assembly flight, STS-88, in the 3rd quarter of FY 1998. "Phase II" upgrades have been added to the program that are required to assure mission supportability into the next century.

Key elements of this budget request are: (1) the continued transition to a single prime contractor for space flight operations: (2) initiation of new Phase II upgrades: and (3) Orbital Maintenance Down Periods (OMDPs) to be conducted at Palmdale, California.

In the Space Shuttle's FY 1998 Congressional request, a Phase III/IV portion of the Upgrade Program was envisioned. Since that time, the Agency formed a Space Transportation Council (STC) to assess advanced transportation areas in both the Office of Space Flight and the Office of Aeronautics and Space Transportation Technology. Technology need studies were conducted by the Space Shuttle program in FY 1997 and FY 1998. In recognition of the value of close collaboration on the technology needs of future reusable launch vehicles, lead responsibility has been consolidated within the Space Transportation Technology program. The Space Transportation Council will provide management oversight and policy direction across the agency's activities in this area. Potential major Shuttle upgrades will be examined under the Future Space Launch industry-led trade studies described in the Space Transportation Technology section. These studies will provide the basis for end-of-decade decisions by NASA and the Administration on pursuing an operational launch system to reduce NASA's launch cost.

STRATEGY FOR ACHIEVING GOALS

The budget structure of the Space Shuttle program consists of two major components: Safety and Performance Upgrades, and Space Shuttle Operations. Safety and performance Upgrades provide for modifications and improvements to the flight elements and ground facilities, including expansion of safety and operating margins and enhancement of Space Shuttle capabilities as well as the replacement of obsolete systems. Shuttle Operations including hardware production, ground processing, launch and landing, mission operations, flight crew operations, training, logistics, and sustaining engineering. In addition, this budget includes funding for facilities related to the Space Shuttle.

The Space Shuttle program's strategy for the Safety and Performance Upgrades budget is to fund those modifications and improvements which will provide for the safe, continuous, and affordable operations of the Space Shuttle system for the foreseeable future. This is an essential element of the launch strategy required for continuing operations supportability of the International Space Station.

The overall strategy for the Shuttle Operations budget is to request funding levels sufficient to allow the Space Flight Operations Contract to meet the intended flight rates, including appropriate contingency planning in both budget and schedule allowances to assure transportation and assembly support to the Space Station program, while at the same time incentivizing the contractor to identify opportunities for reductions in operations costs while still ensuring the safe and reliable operation of the Space Shuttle. The continued transition of activities to the Space Flight Operations Contract represents a key element of this strategy.

BASIS OF FY 1999 FUNDING REQUIREMENT

SAFETY AND PERFORMANCE UPGRADES

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Orbiter improvements	159,900	232,500	234,800
Multifunction-electronic display system	15,900	31,100	5,500
Other orbiter improvements..	144,000	201,400	181,300
[Supportability Upgrades] [included above]..................	[50,000]	[50,000]	48,000
Propulsion upgrades	202.800	176,000	175,700
Space shuttle main engine upgrades..	196,000	170,700	172,800
[Alternate Turbopump program]................................	[79,600]	[72,100]	[63,700]
[Other main engine upgrades]....................................	[116,4001	[98,6001	[109,100]
Solid rocket booster improvements	800	3,500	2,900
Super lightweight tank	6,000	1,800	--
Flight operations & launch site equipment upgrades..........	125.000	138,100	153,500
Flight operation upgrades..	66,400	70,600	38,500
Launch site equipment upgrades	58,600	67,500	115,000
[Supportability Upgrades]...	[20,000]	[45,000]	[52,000]
Construction of facilities	8,300	6,800	7,600
Total.	496,000	553,400	571,600

GENERAL

The Safety and Performance Upgrade program is measured by the success it has in accomplishing the ongoing projects consistent with approved schedule and cost planning, and also the effect these projects have on the overall operation of the Space Shuttle System. Success depends on developing these projects and getting them implemented to help insure the Space Shuttle's safe operation, and improve the reliability of the supporting elements.

The FY 1999 budget request includes activities in the following categories: Orbiter Improvements, Space Shuttle Main Engine (SSME) Upgrades, Launch Site Equipment (LSE) Upgrades and Flight Operations Upgrades, as well as specific, Space Shuttle-related Construction of Facilities. This budget also includes Supportability upgrades to develop more modern systems which will combat obsolescence of vehicle and ground systems in order to maintain the program's viability into the next century. Vendor loss of aging components, high failure rates of older components, high repair costs of Shuttle-specific devices, and negative environmental impacts of some out-dated technologies are areas to be addressed.

The following is a brief description of these activities.

Orbiter Improvements

The Orbiter improvements program provides for enhancements of the Space Shuttle systems, produces space components that are not susceptible to damage, and maintains core skills and capabilities required to modify and maintain the Orbiter as a safe and effective transportation and science platform. These activities are provided by contract arrangements with Boeing North American (formerly, the Rockwell International Space Division) in two major locations in FY 1998: the Downey, California facility provides engineering, manufacturing and testing: and the Palmdale, California operation provides Orbiter Maintenance Down Period (OMDP) support as discussed below. Other activities that support this effort are subsystem management engineering and analysis conducted by Lockheed-Martin Corporation and development and modifications required for support to the extravehicular capability conducted by Hamilton Standard.

Orbiter Maintenance Down Period (OMDP) occurs when each Orbiter is taken out of service periodically for detailed structural inspections and thorough testing of its systems before returning to operational status. This period also provides opportunities for major modifications and upgrades, especially those upgrades that are necessary for improving performance to meet the International Space Station operational profile.

Propulsion Upgrades

The main engine safety and performance upgrade program is managed by the Marshall Space Flight Center (MSFC) and supports the Orbiter fleet with flight-qualified main engine components and the necessary engineering and manufacturing capability to address any failure or anomaly quickly. The Rocketdyne Division of the Boeing North American Corporation is responsible for operating three locations that provide engine manufacturing, major overhaul, components recycle and test. They are:

(1) Canoga Park, California which manufactures and performs major overhaul to the main engines;
(2) Stennis Space Center (SSC), Mississippi for conducting engine development, acceptance and certification tests: and
(3) Kennedy Space Center (KSC), Florida where the engine inspection checkout activities are accomplished at the KSC engine shop.

Engine ground test and flight data evaluation, hardware anomaly reviews and anomaly resolution are managed by the Marshall Space Flight Center (MSFC). The Alternate Turbopump project is also managed by the MSFC under contract with Pratt Whitney of West Palm Beach, FL. The Super Lightweight Tank project is managed by the MSFC and is being accomplished by the Lockheed Martin Corporation at the government-owned Michoud Assembly Facility (MAF) near New Orleans, LA.

Flight Operations and Launch Site Equipment Upgrades

The major flight operations facilities at Johnson Space Center (JSC) include the Mission Control Center (MCC), the flight and ground support training facilities, the flight design systems and the training aircraft fleet that includes the Space Shuttle training aircraft, the T-38 aircraft and the Space Shuttle Carrier Aircraft (SCA). The major launch site operational facilities at KSC include three Orbiter Processing Facilities (OPFs), two launch pads, the Vehicle Assembly Building (VAB), the Launch Control Center (LCC), and three Mobile Launcher Platfornis (MLPs). The most significant upgrade in this account is the Checkout and Launch Control System at KSC.

Construction of Facilities

Construction of Facilities (CofF) funding for Space Shuttle projects is provided in this budget to refurbish, modify, reclaim, replace and restore facilities at Office of Space Flight Centers to improve performance, address environmental concerns of the older facilities, and to ensure their readiness to support the Space Shuttle Operations.

PROGRAM GOALS

NASA policy planning assumes the Space Shuttle will need to be capable of supporting the critical transportation requirements for the assembly of the Space Station and perhaps through 10 years of Space Station operations. In order to maintain a viable, human transportation capability that will operate into the next century and support NASA's launch requirements, specific program investments are required. These investments are consistent with NASA's strategy of ensuring the Space Shuttle remains viable until a new transportation system is operational.

STRATEGY FOR ACHIEVING GOALS

This budget provides funds required to modify and improve the capability of the Space Shuttle to ensure its viability as a safe, effective transportation system and scientific platform. It also addresses increasingly stringent environmental requirements, obsolescence of subsystems in the flight vehicle and on the ground, and capital investments needed to achieve reductions in operational costs. Work continues on the Alternate Fuel Turbopump and new Large Throat Main Combustion Chamber (LTMCC) for the planned introduction of the Block II Space Shuttle Main Engine (SSME). Block IIA engines will fly in mid FY 1998 and Block II in early FY 1999.

The major safety and performance upgrades and their initial flight dates are listed on the following chart on the next page.

MEASURES OF PERFORMANCE

The Safety and Performance Upgrade program is measured by the success it has in accomplishing the ongoing projects consistent with approved schedule and cost planning. Success depends on developing/implementing these projects and to help ensure the

Space Shuttle's safe operation, improve the reliability of the supporting elements, and improving efficiencies to reduce operational costs. This budget addresses all elements of the Space Shuttle program and is managed through an approval process that ensures that new projects are evaluated, approved and initiated on a priority basis, and that existing projects meet established cost and schedule goals. Significant milestones are listed below:

Orbiter Improvements

Multifunction Electronic-Display System (MEDS) - MEDS is a state-of-the-art integrated display system that will replace the current Orbiter cockpit displays with an integrated liquid crystal display system.

Complete MEDS Software Qualification Plan: 1^{st} Qtr FY 1997 Actual: 2^{nd} Qtr FY 1997	Completed MEDS Software development and verification.
Complete MEDS Qualification Testing Plan: 1st Qtr FY 1996 Revised: 1^{st} Qtr FY 1998	Complete hardware qualification testing and start hardware integration and verification testing. The qualification program was extended through this date. No significant impact to initial operating capability is expected. Delay was due to change in glass supplier.
OV-104 Major MOD Plan: 2^{nd} Qtr FY 1998 Actual: 2^{nd} Qtr FY 1998	Installation and checkout of MEDS hardware in OV-104 at Palmdale
MEDS Initial Operational Capability (IOC) Plan: 2^{nd} Qtr FY 1999	First flight of a MEDS equipped Orbiter. (OV-104/STS-92)

Global Positioning System (GPS) - GPS will replace the current TACAN navigational system in the Orbiter navigation system when the military TACAN ground stations will be phased out in the year 2000. The planned readiness date for the Space Shuttle's system is FY 1999.

Complete GPS Preliminary Design Review (PDR) Plan: 2^{nd} Qtr FY 1997 Actual: 2^{nd} Qtr FY 1997	Completion of System Requirements Review will allow design drawings to proceed toward Critical Design Review (CDR)
Complete GPS System	Completion of CDR will allow drawings to be released for production to proceed.

Requirements Review Plan: 2nd Qtr FY 1997 Actual: 3rd Qtr FY 1997	Delay is due to the change from the original, single-string GPS, to the three-string GPS System.
TACAN Removal Plan: 3rd Qtr FY 1998	Remove TACAN at Palmdale based on November 1997 go/no go decision.
Orbiter Install Complete Plan: 4th Qtr FY 1998	Installation and checkout of hardware on OV-104 at Palmdale.
Complete GPS operational capability Plan: 2nd Qtr FY 1999	Initial operation of GPS without TACAN system.

Orbiter Maintenance Down Periods

Initiate Atlantis (OV-104) OMDP Plan: 1st Qtr FY 1998	Conduct routine maintenance and structural inspection. Also install an external airlock, the MEDS upgrade, and hardware for 3-String GPS capability.
Initiate Columbia (OV-102) OMDP Plan: 1st Qtr FY 1999	Conduct routine maintenance and structural inspection. Also, install the MEDS upgrade and hardware for 3-string GPS capability.

Propulsion Upgrades

Super Lightweight Tank - This performance enhancement is designed to provide 7,500 pounds of additional performance for the Space Shuttle to allow rendezvous and operations with the International Space Station. Development was completed in FY 1997 with the successful proof test of the first unit.

Design Certification Review Plan: 3rd Qtr FY 1997 Revised: 4th Qtr FY 1997	The Super Lightweight Tank will provide 7,500 pounds of performance through incorporation of an aluminum-lithium alloy in the external tank structure. Schedule revision was due to problems encountered in welding aluminum lithium.
Deliver first SLWT to KSC for flight Plan: 4th Qtr FY 1997 Revised: 2nd Qtr FY 1998	Final assembly and checkout will be conducted at the Michoud Assembly Facility **(MAF)** in New Orleans, Louisiana. Schedule revision was due to need to perform multiple proof tests to verify welds.

Space Shuttle Main Engine Safety Improvements - Introduction of Block I and Block II changes into the Space Shuttle's Main Engine program will improve the margin of safety by a factor of two. The interim Block IIA configuration (Block I without the High-Pressure Fuel Turbo Pump (HPFTP))implements the safety and performance margins provided by the LTMCC while the HPFTP development problems are solved. The last Block IIA flight is planned for FY 1999.

High Pressure Fuel Turbopump Critical Design Review (CDR)	Completion of CDR will allow production to proceed for implementation of the Alternate Turbopump high pressure fuel pump into the Block II Engine upgrade.
Plan: 3rd Qtr FY 1996	Revised due to testing delays
Revised: 2nd Qtr FY 1997	Opted for IIA configuration because of new HPFTP delays
Revised: 1st Qtr FY 1998	Block II status under review at MSFC
Revised: 3rd Qtr FY 1998	

First flight of the Block II engine	The high pressure fuel turbopump will be combined with the LTMCC.
Plan: 4th Qtr FY 1997	Revised due to testing delays
Revised: 1st Qtr FY 1998	Opted for IIA configuration because of HPFTP delays.
Revised: 2nd Qtr FY 1998	Block II status under review at MSFC
Revised: 4th Qtr FY 1998	

SPACE SHUTTLE PROGRAM SAFETY AND PERFORMANCE ENHANCEMENTS

HEDS STRATEGIC PLAN

Fiscal Year	1995	1996	1997	1998	1999	2000	2001	2002
Alternate Turbopump Development								
-- Oxidizer Turbopump - First Flight	▲ 7/95							
-- Fuel Turbopump - First Flight				A- 5/98	A NET 12/98			
Large Throat Main Combustion Chamber - First Flight				A 1/98				
Super Lightweight Tank - First Flight				a 5/98				
Main Engine Phase II + Powerhead - First Flight	▲ 7/95							
Auxilary Power Unit - New Gas Generator Valve - Ready for Flight			▲ 7/97					
Multifunction Electronic Display System - First Flight					A 1/99			

Flight Operations and Launch Site Equipment Upgrades- Upgrades to the Mission Control Center were completed in FY 1997 period which improved operations reliability and maintainability and also took advantage of the state-of-the-art technology in displays and controls. In addition, upgrades continued in FY 1998 to the Launch Site Equipment at KSC will increase reliability and reduce obsolescence.

Deliver first two Portable Purge Units Plan: 3rd Qtr FY 1997 Actual: 3rd Qtr FY 1997	First units delivered and tested by user. Revised due to delay in award of contract.
CLCS Program Authority to Proceed Plan: 1st Qtr FY 1997 Actual: 1st Qtr FY 1997	The Checkout and Launch Control System (CLCS)replace the 1970's Launch Processing System (LPS). Began the formal process of CLCS design and acquisition.
First Launch Using CLCS Plan: 1st Qtr FY 2001	Launch the first Shuttle from a CLCS - equipped Launch Control Center.
Complete Migration of CLCS to all Firing Rooms and Simulators Plan: 4th Qtr FY 2001	CLCS fully operational for flight support. This will result in a significant reduction in operating cost, **up** to 50%, of the current LPS.

Construction of Facilities

Restore Firex Pumps and Piping at LC-39	Restoration is needed. Pumps are currently inadequate to provide spray coverage during an emergency.
Complete Phase I Plan: 3rd Qtr. FY 97 Actual: 4th Qtr. FY 97	This project replaced underrated firex loop piping and components, and provides fire protection at Pads A and B. Additional work necessary to complete the associated controls including control cable installation and termination on Pad B.
Start Phase II Plan: 2nd Qtr. FY 96 Actual: 2nd Qtr. FY 97	This project removes and replaces existing Firex pumps, motors, refurbishes diesels, and installs a new underground pipe between the pump station and Pads A and B. Completion of this project scheduled for the 3rd Quarter of FY 1999.

Replace Component Refurbishment and Chemical Analysis Facility at KSC	This facility was in non-compliance with OSHA standards and overcrowded and insulated with asbestos.
Complete Phase I Plan: 1st Qtr. FY 97 Actual: 3rd Qtr. FY 97	Completing this effort in FY 1997 is earliest opportunity to comply with requirements during cleaning and degreasing operations.
Complete Phase II Plan: 4th Qtr. FY 97 Revised: 1st Qtr. FY 98	Complete activation of component refurbishment chemical analysis (CRCA)building.
Complete SSME Processing Facility at KSC Plan: 2nd Qtr. FY 98	Project provides for construction of an addition to the east end of the lower level of OPF-3 Annex to provide shop area for SSME processing. The facility will allow for safely and efficiently processing engines.
Rehabilitation of 480V Electrical Distribution System at MAF	External Tank manufacturing building
Start Phase I Plan: 2nd Qtr. FY 97 Actual: 2nd Qtr. FY 97	Phase 1, Final Assembly Area Project will upgrade the power distribution system from below the substation to the respective tools (Labor intensive project working over flight hardware). This phase should be completed by the 2nd Quarter of FY 1999.
Start Phase II Plan: 1st Qtr. FY 98	Phase II, ET Sub-Assembly Area Project will upgrade the power distribution system from below the substation to the respective tools. This phase should be completed in the 1st Quarter of FY 2000.
Start Phase III Plan: 1st Qtr. FY 99	Phase III, Substations 17A/ 17B will replace the core system, transformers, switch gear, breakers and oil switches. Includes some cable, cable tray, and panel upgrades. This phase should be completed in the 1st Quarter of FY 2001.
Complete Pad B Fixed Service Structure (FSS)Elevator at LC-39 Plan: 4th Qtr. FY 97 Actual: 4th Qtr. FY 97	This project replaces the elevator cabs, cables and controls to eliminate severely deteriorated and archaic equipment.

Start Pad B Chiller Replacement at LC-39 Plan: 2nd Qtr. FY 97 Actual: 2nd Qtr. FY 97	This project replaces the aged facility chillers at Launch Complex 39, Pad B, and reconfigures the system for more efficient maintenance. The planned completion date for this project is 2nd Quarter of FY 1999.
Start Rehabilitation of High Pressure Industrial Water System at SSC Plan: 3rd Qtr. FY 97 Actual: 1st Qtr. FY 97	This project initiates the restoration of the High Pressure Industrial Water Plant to insure system reliability in support of the Space Shuttle Main Engine testing. The planned completion date of this project is 2nd Quarter of FY 1999.
Start Restoration of Pad A PCR Wall and Ceiling Integrity at Launch Complex (LC)-39 Plan: 3rd Qtr. FY 98	This project provides for repair and replacement of damaged Payload Change Out Room (PCR) wall panels (Sides 1, 2, 3, & 4), replacement or elimination of deteriorated and leaking access doors, and other needed replacement and restoration. The modification will eliminate degrading flexducts and filter housings, improve pressurization of the PCR, provide an even distribution of air flow, and provide safe personnel access for maintenance and repair. This project is planned for completion in the 1st Quarter of FY 2000.
Start Pad A Surface and Slope Restoration at LC-39 Plan: 3rd Qtr. FY 98	This project provides for repair of the Pad A surface concrete, pad slopes, and the crawlenvay grid path. This project is scheduled to be completed in the 1st Quarter of FY 2000.
Start Repair of Pad A Flame Deflector & Trench at LC-39 Plan: 1st Qtr. FY 99	This project provides for repair of the fire resistant surface of the Main and SRB flame deflector, repair/replacement of damaged and corroded structural members, and repair/replacement of bricks in the Flame Trench wall. Plan completion date is 1st Quarter FY 2000.
Start Pad A FSS Elevator restoration at LC-39 Plan: 1st Qtr. FY 99	This project modifies the elevator structural on Pad B, and refurbishes the elevator cabs, cables and cableway. Planned completion date is the 1st Quarter of FY 2000.

ACCOMPLISHMENTS AND PLANS

A significant portion of the Safety and Performance Upgrades (S&PU) budget is dedicated to avoiding and preventing deleterious and costly effects of obsolescence, especially at a time when the program is undertaking the challenge of reducing the costs of operations. This portion of the budget contains projects that impact every element of the Space Shuttle vehicle. The S&PU budget will continue to support the replacement of the Orbiters' cockpit displays with Multifunction Electronic Display System (MEDS), replacing Tactical Air Command and Navigation System (TACAN) with Global Positioning System (GPS), upgrading the T-38 aircraft with maintainable systems, replacing elements of the launch site complex, upgrading major elements of the training facilities at Johnson Space Center, testing of main engine components at SSC, testing of Orbiter reaction control systems at the White Sands Test Facility, and replacing critical subsystems in the Kennedy Space Center facility complex.

In addition, this request includes funds for Shuttle Supportability Upgrades which will maintain availability of the Space Shuttle fleet for the foreseeable future.

The Space Shuttle program rationale for supportability upgrades is founded on the premise that safety, reliability, and mission supportability improvements must be made in the Shuttle system to continue to provide safe and affordable operations into the next century. These will enable safe and efficient Shuttle operations during the Space Station era while providing a robust testbed for advanced technologies and a variety of customers.

The Space Shuttle Upgrade activity will be planned and implemented from a system-wide perspective. Individual upgrades will be integrated and prioritized across all flight and ground systems, insuring that the upgrade is compatible with the entire program and other improvements. Selection of new upgrades through the review process approved by the Associate Administrator for Space Flight, the Program Management Council (PMC) and the Administrator will be utilized. Implementation authority and responsibility will be delegated to the Lead Center Director for the Shuttle Program with the Shuttle Program Manager and the projects. Space Shuttle upgrades will be developed and implemented in a phased manner supporting one or more of the following program goals:

- Improve Space Shuttle system safety and/or reliability
- Support the Space Shuttle program manifest/Space Station
- Improve Space Shuttle system support
- Reduce Space Shuttle system operations cost

The phasing strategy will be coordinated with the Reusable Launch Vehicle (RLV) project management, and other development projects, to capture common technology developments, while meeting the Shuttle manifest. This phasing strategy should allow the incorporation of additional, more comprehensive upgrades to the Space Shuttle system while benefiting other programs and technologies. Candidate upgrades in the initial phases will utilize state-of-the-art technology and provide safety/reliability, supportability, and/or cost (improvement) advantages. Candidate designs in the initial phases would maintain the current Shuttle mold lines and system/subsystem interfaces.

Orbiter Improvements

Orbiter improvements provide for modifications and upgrades to ensure compatibility of the Space Shuttle vehicles with the new Space Station operational environment. Orbiter weight reductions have been identified where operating experience or updated requirements allow selected items to be changed without impact to crew safety or mission success. The Orbiter weight will be reduced by changing the exterior thermal protection materials on certain portions of the Orbiter, deleting portions of the Orbital Maneuvering and Reaction Control Systems (OMS/RCS) that are no longer required, changing the material on the "flipper doors" that provide a seal between the Orbiter wing and its control surfaces, and development of lighter weight crew seats for the cockpit.

There were several improvements implemented in the Space Shuttle vehicle in FY 1997. In the Orbiter, fuel cell single cell monitoring system was installed in response to fuel cell problems encountered during STS-83. The new monitoring system was developed and implemented in the first Orbiter in less than four months. Other Orbiter improvements included new Digital Autopilot (DAP) software designed to reduce fuel consumption in orbit, and new launch trajectory software to increase performance margins and enable the deletion of the Bermuda tracking station for communications during launch. The Solid Rocket Booster also received several upgrades designed to reduce the expense of recovering and refurbishing the boosters. Those upgrades include a saltwater activated mechanism to release the parachutes, improvements to the parachutes themselves, and a modification to the aft skirt brackets.

During FY 1997, Endeavor (OV-105) completed its OMDP and has reentered the fleet in time to fly STS-89 in January 1998. In FY 1998, Atlantis (OV-104) will enter OMDP for normal maintenance, structural inspections, and will also be modified for docking with the International Space Station.

The Multifunction Electronic Display System (MEDS) upgrade will replace the current Orbiter cockpit displays which are early 1970's technology. The current displays which provide command and control of the Space Shuttle are "single string" electro-mechanical devices that are experiencing life related failures and are maintenance intensive. Difficulty in obtaining parts, some of which are no longer manufactured, is becoming more prevalent. The MEDS upgrade is a state-of-the-art, multiple redundant liquid crystal display (LCD) system. MEDS will enhance the reliability of the cockpit display system, resolve the parts availability problem, and provide a much more flexible and capable display system for the crew. This upgrade will bring the Orbiter up to current aircraft standards, benefiting the training of new astronauts directly. Secondary benefits of MEDS are reductions in the Orbiter's weight and power consumption. The MEDS upgrade includes the design effort and production of modification kits for the four Orbiter vehicles. New MEDS ground support hardware is also being designed. When procured and installed it will upgrade the appropriate simulators, test equipment, and laboratories. MEDS will be installed in the Orbiters and tested during the planned OMDPs, beginning with the FY 1998 OV-104 OMDP.

Expansion of the effort to replace the Orbiter's TACAN landing navigation system with the Global Positioning System (GPS) began in FY 1995. This expansion will include an increased interaction of the GPS receiver with the Orbiter backup flight software, and outfitting two more Orbiters with a GPS test receiver. A number of development flights will take place with increasing GPS capability while still utilizing TACAN navigation. The first flight of a complete GPS system is planned for 1999.

Propulsion Upgrades

The most complex components of the Space Shuttle Main Engine (SSME) are the high pressure turbopumps. Engine system requirements result in pump discharge pressure levels from 6000 to 8000 psi and turbine inlet temperatures of 2000 Degrees F. In reviewing the most critical items on the SSME that could result in a catastrophic failure, 14 of the top 25 are associated with the turbopumps. The current pumps' dependence on extensive inspection to assure safety of flight have made them difficult to produce and costly to maintain. The Alternate Turbopump Program (ATP) contract with Pratt & Whitney was signed in December 1986 and called for parallel development of both the High Pressure Oxidizer Turbopump (I-IPOTP) and the High Pressure Fuel Turbopump

(HPFTP) to correct the shortcomings of the existing high pressure turbopumps. This objective is achieved by: utilizing design, analytical, and manufacturing technology not available during development of the original components; application of lessons learned from the original SSME development program: elimination of failure modes from the design; implementation of a build-to-print fabrication and assembly process: and full inspection capability by design. The turbopumps utilize precision castings, reducing the total number of welds in the pumps from 769 to 7. Turbine blades, bearings, and rotor stiffness are all improved through the use of new materials and manufacturing techniques. The SSME upgrades will expand existing safety margins and reduce operational costs.

The SSME Powerhead is the structural backbone of the engine. The Phase 11+ Powerhead will reduce the number of welds, improving producibility and reliability.

The heat exchanger uses the hot turbine discharge gases to convert liquid oxygen in a thin walled coil to gaseous oxygen for pressurization of the external oxygen tank. The current heat exchanger coil has seven welds exposed to the hot gas environment. A small leak in one of these welds would result in catastrophic failure. The new Single Coil Heat Exchanger eliminated all seven critical welds and tripled the wall thickness.

The Large Throat Main Combustion Chamber (LTMCC) development will result in lower pressures and temperatures throughout the engine system thereby increasing the overall Space Shuttle system flight safety and reliability. The wider throat area accommodates additional cooling channels. Consequently, hot gas wall temperatures are significantly reduced increasing chamber life. The LTMCC design also incorporates new fabrication techniques to reduce the number of critical welds and improve the producibility of the chamber. Development on the powerhead, heat exchanger and LTMCC are all being performed under contract with the Rocketdyne division of the Boeing North American Corporation.

The "block" change concept for incorporating changes into the main engine was introduced and baselined during FY 1994. The Phase 11+ Powerhead, the Single Coil Heat Exchanger and the new high pressure oxidizer turbopump comprise Block I. This change was introduced and flown for the first time in July 1995. The Block II is scheduled to be flown in early FY 1999 and consists of the Large Throat Main Combustion Chamber and the alternate high pressure fuel turbopump. The end result of these engine improvements is an increase in the overall engine durability, reliability and safety margin, and producibility. This is consistent with NASA's goals of decreasing failure probability and reducing Space Shuttle costs.

Increased safety margins and launch reliability on the Space Shuttle will also be realized through the implementation of new sensors (temperature, pressure and flow) for use in the SSME. SSME history has shown that the engine is more reliable than the instrumentation system; however, a transducer failure could result in a flight scrub or on-pad abort, failure to detect an engine fault, or an in-flight abort. These sensor upgrades are essential to improving the reliability of the Space Shuttle's launch capability.

The SLWT program is a result of NASA's desire to enhance the payload capability of the Space Shuttle System to support the Space Station Program. In FY 1996, the verification testing of the Aluminum Lithium Test Article (ALTA) was successfully completed. This test demonstrated the capability of the liquid hydrogen barrel section of the SLWT to withstand flight loads with sufficient margin.

The SLWT is due to complete final assembly and proof testing in January 1998 in preparation for delivery to KSC. First flight is planned for May 1998 on STS-91.

Flight Operations and Launch Site Equipment Upgrades

These upgrades support pre-launch and post-launch processing of the four Orbiter fleet. Key enhancements funded in launch site equipment include: replacement hydraulic pumping units that provide power to Orbiter flight systems during ground processing; replacement of 16-year old ground cooling units that support all Orbiter power-on testing: replacement of communications and tracking Ku-band radar test set for the labs in the Orbiter Processing Facility and High Bays that supports rendezvous capability and the missions: communications and instrumentation equipment survivability projects that cover the digital operational intercom system, major portions of KSC's 17-year old radio system, and the operational television system: improvement of the Space Shuttle operations data network that supports interconnectivity between Shuttle facilities and other KSC and off-site networks: replacement storage tanks and vessels for the propellants, pressurants, and gases: an improved hazardous gas detection system; and fiber optic cabling and equipment upgrades.

A new Checkout and Launch Control System (CLCS) was approved for development at KSC in FY 1997. The CLCS will upgrade the Shuttle launch control room systems with state-of-the-art commercial equipment and software in a phased manner to allow the existing flight schedule to be maintained. The CLCS will reduce operations and maintenance costs associated with the launch control room by as much as 50%, and will provide the building blocks to support future vehicle control system requirements. The Juno and Redstone phases of the CLCS were delivered in FY 1997. In these phases the initial integration platform was defined, the engineering platform was installed, and the interface with the math models was established.. The Thor and Atlas phases are scheduled for completion in FY 1998. During these phases, the initial applications for the Orbiter Processing Facility will be developed, the math models will be validated, an interface to the Shuttle Avionics Integration Lab will be established, and hardware testing will be done. The Titan and Scout phases of CLCS are planned for FY 1999 during which Orbiter automated power-up will be developed, peripheral locations will be upgraded, and selected vertical testing will be done. In FY 2000, the Delta and Saturn phases will be accomplished which includes completion of all launch application development, completion of software certification and validation, and a complete integrated flow demonstration. By the end of FY 2000, Operations Control Room-1 will be fully operation, followed by certification in FY 2001. The first Shuttle launch using the CLCS is scheduled for FY 2001 with full implementation to be completed one year later.

The Hardware Interface Modules (HIM), which are electrical command distribution systems that support the launch processing system (LPS) at KSC, are over 25 years old and have experienced an increased failure rate and higher cost of repair over the past several years. The HIM upgrade replaces all chassis and cards with state-of-the-art "off the shelf' hardware to improve system reliability and maintainability. Production and installation should be complete in FY 1999.

A cable plant upgrade at KSC replaces the miles of cables which support a wide variety of Space Shuttle facilities. Many of these cables were installed in the 1960s and are suffering from corrosion and increasing failure rates. Replacement will reduce the potential for disruption to critical Space Shuttle operations as well as have a direct maintenance benefit. This activity will reduce the possibility of launch delays, increase communication system spares availability, and enhance the reliability of data, instrumentation, voice, and video communications. This upgrade will replace the wide-band distribution system and the lead/antimony sheath cables with fiber optics and plastic sheath, gel-filled cable. In addition, many field terminals will be replaced or upgraded. The upgrade should be complete in late FY 1998.

Funds for other activities include implementing required modifications and upgrades on the T-38 aircraft used for space flight readiness training, capability improvements for weather prediction, and enhancements on information handling to improve system monitoring, notably for anomaly tracking.

Construction of Facilities (CoF)

FY 1997 CoF funding was concentrated on KSC, MAF, and SSC facilities. At KSC, there were two projects which are both at Launch Complex Pad B - the replacement of Pad B chiller system and the restoration of the Fixed Support Structure Elevator System. Both systems are over 25 years old and are past their economic life expectancy. These systems are part of a critical path for launch criteria assurance. At MAF, the rehabilitation and modification of the 480-volt electrical system are necessary to protect critical manufacturing operations in the final assembly and major weld areas for the manufacturing of the External Tank (ET). At SSC, the restoration of the High Pressure Industrial Water Plant included the overhaul of three diesel engines for the deluge water system and two diesel engines for the electrical generation system. These engines drive the water pumps and electrical generators that provide cooling water and reliable power for all three SSME test stands for flight certification and development testing.

FY 1998 CoF will provide for improvements for facilities at KSC and MAF. At **MAF,** this project is phase II of IV to rehabilitate the 480-volt electrical distribution system that is critical to the manufacturing of the external tank. At KSC, one project will be restoring the walls and ceiling that provides a controlled environment to perform pre-flight services of Space Shuttle hardware at Pad A/LC-39 Payload Change-Out Room (PCR). The other project at KSC will restore the concrete surfaces and slope of Pad A/LC-39 structure.

FY 1999 CoF funding will provide for improvements for facilities at KSC and MAF. At KSC, there are two projects which are both at Launch Complex Pad A - the restoration of the Fixed Support Structure Elevator System and the repair of the fire resistant surface of the Main and SRB flame deflector, repair/replacement of damaged and corroded structural members, and repair/replacement of bricks in the Flame Trench wall. At MAF, there are two projects Phase III of IV for the rehabilitation of the 480-volt electrical distribution system and Repair Cell E Common solution return and lining. For additional details on these projects, please refer to the Mission Support - Construction of Facilities budget.

BASIS OF FY 1999 FUNDING REQUIREMENT

SHUTTLE OPERATIONS

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Orbiter and integration	492,600	502,900	573,400
[Orbiter]	[124,700]	[126,200]	[113,900]
[System integration]	[367,900]	[376,700]	[459,500]
Propulsion	1,124,700	1,061,800	1,093,400
[External tank]	[352,400]	[341,300]	[404,800]
[Space shuttle main engine]	[208,300]	[204,600]	[175,600]
[Reusable solid rocket motor]	[412,800]	[380,400]	[362,700]
[Solid rocket booster]	[151,200]	[135,500]	[150,300]
Mission and launch operations	847,600	804,700	820,600
[Launch and landing operations]	[801,400]	(710,100]	[728,400]
[Mission and crew operations]	[46,200]	[94,600]	[92,200]
Total	2,464,900	2,369,400	2,487,400

GENERAL

Space Shuttle operations requirements are met through a combination of funds received from Congressional appropriations and reimbursements received from customers whose payloads are manifested on the Space Shuttle. The reimbursements are applied consistent with the receipt of funds and mission lead times and are subject to revision as changes to the manifest occur. The FY 1998 planned standard service reimbursements total $11.9 million, with $57.4 million (due to the Shuttle Radar Topograpy Mission) in reimbursements assumed for FY 1999, which offset the total budget for the Space Shuttle, and have been assumed in the NASA direct funding requirements identified above for this budget request.

The Space Shuttle operations budget includes sustaining engineering, hardware and software production, logistics, flight and ground operations, and flight crew operations for all elements while continuing to pursue environmentally necessary operations and manufacturing improvements. The single, prime contract is the Space Flight Operations Contract (SFOC) held by United Space Alliance comprising almost one-half of the Operations budget. As development items are completed, additional effort will be transitioned into SFOC.

Orbiter and Integration

The Orbiter project element consists of the following items and activities:

(1) Orbiter logistics: spares for the replenishment of Line Replacement Units (LRUs) and Shop Replacement Units (SRUs) along with the workforce required to support the program:
(2) Production of External Tank (ET) disconnect hardware:
(3) Flight crew equipment processing as well as flight crew equipment spares and maintenance, including hardware to support Space Shuttle extravehicular activity:
(4) Various Orbiter support hardware items such as Pyrotechnic-Initiated Controllers (PICs), NASA Standard Initiators (NSI's), and overhauls and repairs associated with the Remote Manipulator System (RMS); and
(5) The sustaining engineering associated with the Orbiter vehicles.

The major contractors for these Orbiter activities are United Space Alliance for operations: Boeing North American for External Tank disconnects and Orbiter sustaining engineering: and Hamilton Standard and Boeing for flight crew equipment processing.

System integration includes those elements managed by the Space Shuttle Program Office at the Johnson Space Center (JSC) and conducted primarily by United Space Alliance, including payload integration into the Space Shuttle and systems integration of the flight hardware elements through all phases of flight, Payload integration provides for the engineering analysis needed to ensure that various payloads can be assembled and integrated to form a viable and safe cargo for each Space Shuttle mission. Systems integration includes the necessary mechanical, aerodynamic, and avionics engineering tasks to ensure that the launch vehicle can be safely launched, fly a safe ascent trajectory, achieve planned performance, and descend to a safe landing. In addition, funding is provided for multi-program support at JSC.

Propulsion

External Tanks/Super Lightweight Tanks are produced by Lockheed Martin Corporation in the Government-Owned/Contractor-Operated (GOCO) facility near New Orleans, LA. This activity involves the following:

(1) Procurement of materials and components from vendors:
(2) Engineering and manufacturing personnel and necessary environmental manufacturing improvements.
(3) Support personnel and other costs to operate the GOCO facility: and
(4) Sustaining engineering for flight support and anomaly resolution.

The program began delivering Super Lightweight Tanks to KSC in support of the performance enhancement goal required by the Space Station in FY 1998. Only recurring costs associated with the Super Lightweight Tank are included in this account. Non-recurring costs are accounted for in the Safety and performance Upgrades budget. The External Tank contract is scheduled to be transitioned into Phase II SFOC in FY 1999.

The Space Shuttle Main Engine (SSME)operations budget provides for overhaul and repair of main engine components, procurement of main engine spare parts, and main engine flight support and anomaly resolution. In addition, this budget includes funding to the Department of Defense for Defense Contract Management Command (DCMC)support in the quality assurance and inspection of Space Shuttle hardware: and funds for transportation and logistics costs in support of SSME flight operations. Rocketdyne, a division of Boeing North American Corporation, provides the bulk of the engine components for flight as well as sustaining engineering, integration, and processing of the SSME for flight.

The Solid Rocket Booster (SRB) project supports:

(1) Procurement of hardware and materials needed to support the flight schedule:
(2) Work at various locations throughout the country for the repair of flown components:
(3) Workforce at the prime contractor facility for integration of both used and new components into a forward and an aft assembly; and
(4) Sustaining engineering for flight support.

USBI, Inc., is the prime contractor on the SRB and conducts SRB retrieval, refurbishment and processing at KSC. USBI completed the process of consolidating their workforce at Kennedy Space Center from Huntsville, Alabama. The SRB contract is the first major element to be transitioned into Phase II of the SFOC Contract in FY 1998.

The Reusable Solid Rocket Motor (RSRM) project includes:

(1) Purchase of solid rocket propellant and other materials to manufacture motors and nozzle elements.
(2) Workforce to repair and refurbish flown rocket case segments, assemble individual case segments into casting segments and other production operations including shipment to the launch site:
(3) Engineering personnel required for flight support and anomaly resolution: and
(4) New hardware to support the flight schedule required as a result of attrition.

Thiokol of Brigham City, Utah is the prime contractor for this effort.

Mission and Launch Operations

Launch and Landing Operations provides the workforce and materials to process and prepare the Space Shuttle flight hardware elements for launch as they flow through the processing facilities at the Kennedy Space Center (KSC). The primary contractor is United Space Alliance. This category also funds standard processing and preparation of payloads as they are integrated into the Orbiter, as well as procurement of liquid propellants and gases for launch and base support. It also provides for support to landing operations at KSC (primary), Dryden Flight Research Center (back-up) and contingency sites.

Operation of the launch and landing facilities and equipment at KSC involves refurbishing the Orbiter, stacking and mating of the flight hardware elements into a launch vehicle configuration, verifying the launch configuration, and operating the launch processing system prior to lift-off. Launch operations also provides for booster retrieval operations, configuration control, logistics, transportation, inventory management, and other launch support services. This element also provides funds for:

(1) Maintaining and repairing the central data subsystem, which supports Space Shuttle processing as an on-line element of the launch processing system;
(2) Space Shuttle-related data management functions such as work control and test procedures:
(3) Purchase of equipment, supplies and services: and
(4) Operations support functions including propellant processing, life support systems maintenance, railroad maintenance, pressure vessel certification, Space Shuttle landing facility upkeep, range support, and equipment modifications.

Mission and Crew Operations include a wide variety of pre-flight planning, crew training, operations control activities, flight crew operations support, aircraft maintenance and operations, and life sciences operations support. The primary contractor is US Alliance. The planning activities range from the development of operational concepts and techniques to the creation of detailed systems operational procedures and checklists. Tasks include:

(1) Flight planning;
(2) Preparing systems and software handbooks:
(3) Defining flight rules;
(4) Creating detailed crew activity plans and procedures:
(5) Updating network system requirements for each flight:
(6) Contributing to planning for the selection and operation of Space Shuttle payloads; and
(7) Preparation and plans for International Space Station assembly.

Also included are the Mission Control Center (MCC), Integrated Training Facility (ITF), Integrated Planning System (IPS), and the Software Production Facility (SPF). Except for the SPF (Space Shuttle only), these facilities integrate the mission operations requirements for both the Space Shuttle and International Space Station. Flight planning encompasses flight design, flight analysis, and software activities. Both conceptual and operational flight profiles are designed for each flight, and the designers also help to develop crew training simulations and flight techniques. In addition, the flight designers must develop unique, flight-dependent data for each mission. The data are stored in erasable memories located in the Orbiter, ITF Space Shuttle mission simulators, and MCC computer systems. Mission operations funding also provides for the maintenance and operation of critical mission support facilities including the MCC, ITF, IPS and SPF. Finally, Mission and Crew Operations include maintenance and operations of aircraft needed for flight training and crew proficiency requirements. Other support requirements are also provided for in this budget, including engineering tasks at JSC which support flight software development and verification. The software activities include development, formulation, and verification of the guidance, targeting, and navigation systems software in the Orbiter. The Flight Software Contract with Lockheed Martin will transition into the Phase II of the SFOC Contract in FY 1998.

PROGRAM GOALS

The goal of Space Shuttle Operations is to provide safe, reliable, and effective access to space. The flight rate for the program continues to be budgeted at an average of seven flights annually with surge capability to eight flights. Eight flights were flown in FY 1997, and six flights are planned in FY 1998. Eight flights are planned for FY 1999.

STRATEGY FOR ACHIEVING GOALS

The Space Shuttle program is aggressively continuing to reduce the cost of operations. Since FY 1992, cost reduction efforts have been successful in identifying and implementing program efficiencies and specific content reductions. Space Shuttle project offices and contractors have been challenged to meet reduced budget targets.

United Space Alliance (USA) was awarded the Space Flight Operations Contract (SFOC) on October 1, 1996. It includes a phased approach to consolidating operations into a single prime contract for operational activities. The first phase began in late 1996 with 12 operational and facility contracts being consolidated from the majority of the effort previously conducted by Lockheed Martin and Boeing North American (the two corporations which comprise the US Alliance joint venture). The second phase will add other operations work to the contract after the contractor has had an appropriate amount of time to evolve into its more responsible role in phase I. Transition will take another 1-2 years and employ approximately 7300 equivalent persons at steady state. All transitions will be completed in FY 2000. The reasons for this phased approach are two-fold:

1. The ongoing major development projects (e.g. SLWT, MEDS, ATP, etc.) will be completed.
2. The transition to the prime can occur at a more measured pace.

The roles and missions of the contractor and government relationships have been defined to insure program priorities are maintained and goals are achieved. The SFOC contractor is responsible for flight, ground, and mission operations of the Space Shuttle. The accountability of its actions and those of its subcontractors will be evaluated and incentivized through the use of a combined award/incentive fee structure of the performance-based contract. NASA as owner of assets, customer of operations services, and director of launch/flight operation, is responsible for (a)surveillance and audit to ensure compliance with SFOC requirements, and (b)internal NASA functions. Further, NASA retains chairmanship of control boards and forums responsible for acceptance/rejection/waiver of Government requirements while the SFOC contractor is responsible for requirement implementation. The SFOC contractor is required to document and maintain process/controls necessary to ensure compliance with contract requirements and to sign a certification of flight readiness (CoFR) to that effect for each flight..

MEASURES OF PERFORMANCE

Since the Space Shuttle program has both an operational and development component, performance measures related to the Space Shuttle program reflect a number of different activities ranging from missions planned and time on-orbit in Shuttle Operations, to development milestones planned for the Safety and Performance Upgrades program. The following sets of diverse metrics can be utilized to assess overall program performance.

Ouerations Metrics	FY 1997 Revised plan	FY 1997 Actual	FY 1998 Plan	FY 1998 Current	FY 1999 Plan
Number of Space Shuttle Flights*	7	8	7	6	8
Shuttle Operations Workforce (Prime Contractor (equivalent personnel))	16,519	16,519	16,478	16,023	15,550
Space Shuttle Processing Overtime Required	3%	3%	3%	3%	3%
Number of Days On-orbit	90	94	76	68	90
Number of Primary Payloads Flown	9	10	8	8	9

* Mission added for MSL-1 Reflight (STS-94).

Space Shuttle Missions and Primary Pavloads

FY 1997		plan	Actual
STS-80/Columbia	Wake Shield Facility-3 (WSF-3)/OREFUS-SPAS-02	November 1996	November 1996
STS-81/Atlantis	Russian Space Station Mir (Mir-5)/Spacehab	December 1996	January 1997
STS-82/Discovery	Hubble Space Telescope Servicing Mission (MSTSM-02)	February 1997	February 1997
STS-83/Columbia	Microgravity Science Laboratory (MSL-1)	March 1997	April 1997
STS-84/Atlantis	Russian Space Station Mir (Mir-6)/Spacehab	May 1997	May 1997
STS-94/Columbia	MSL Reflight	--	July 1997
STS-85/Discovery	Japan Manipulator Flight Demonstration/CRISTA-SPAS-02	July 1997	August 1997
STS-86/Atlantis	Space Station Mir (Mir-7)	September 1997	September 1997

FY 1998		plan	
STS-87/Columbia	Microgravity Payload (USMP-04)/Spartan 201-04	November 1997	November 1997
STS-89/Endeavour	Russian Space Station Mir (Mir-8)/Spacehab	January 1998	
STS-90/Columbia	Neurolab	April 1998	
STS-91/Discovery	Russian Space Station Mir (Mir-9)/Spacehab	May 1998	
STS-88/Endeavour	Space Station #1 (Node 1)(ISS-01-2A)	July 1998	
STS-93/Colunibia	AXAF (under review)	August 1998	

FY 1999		plan
STS-95/Discovery	Hubble Orbital System Test (HOST)/Spacehab	October 1998
STS-96/Endeavour	Space Station #2 Spacehab Cargo Module (ISS-02-2A. 1)	December 1998
STS-92/Atlantis	Space Station #3 (ITS-Z1)(ISS-03-3A)	January 1999
STS-97/Discovery	Space Station #4 (PV Module) (ISS-04-4A)	April 1999
STS-98/Endeavour	Space Station #5 (US Lab) (ISS-05-5A)	May 1999
STS-99/Atlantis	Space Station #6 (MPLM) (ISS-06-6A)	June 1999
STS-100/Discovery	Space Station #7 (Airlock (ISS-07-7A)	August 1999
STS-101/Endeavour	Shuttle Radar Topography Mission (SRTM)	September 1999

The Space Shuttle program currently provides launch support for space science missions accommodating universities and industry as a space laboratory and technology research vehicle. Beginning in FY 1998, its primary mission will be to support the on-orbit assembly and operations of the International Space Station. The Shuttle is also the only U.S. vehicle that provides human transportation to and from orbit. In FY 1997, 52 crew members flew approximately 818 days, including time spent by an American astronaut aboard Mir. In FY 1998, **37** crew members are planned to fly approximately 669 days, including time spent by American astronaut aboard Mir. This will be followed by approximately 60 crew members flying 810 crew days in FY 1999, including time spent by Americans aboard the International Space Station.

To supplement the network of management reviews and government oversight functions, NASA continues to seek specific objective measurements of overall performance of the Space Shuttle program. In order to permit rapid review by the program managers, the Shuttle program has devised a series of "stoplight" metrics. The metrics are devised whereby certain program aspects are measured against established limits or program parameters and then translated into the appropriate green, yellow or red indicators. Among the metrics displayed in this manner are in-flight anomalies, monthly cost rate, Shuttle processing monthly mishaps, Orbiter systems and line replaceable unit (LRU) problem reports, Shuttle processing contract overtime percentage, arid KSC quality surveillance error rate. The Shuttle program also tracks its launch history, monitoring the number of liftoff attempts per mission, and characterizing any delays or scrubs as to technical, weather or operational-related reasons.

ACCOMPLISHMENTS AND PLANS

In FY 1997, the Space Shuttle launched eight flights successfully including three flights to the Russian Mir Space Station. Additional flights deployed the Wake Shield Facility (WSF-3) and OREFUS-SPAS-02; and the Japan Manipulator Flight Demonstration as well as CRISTA-SPAS-02 pallet mission. The second Hubble Space Telescope Servicing Mission was conducted, and the Microgravity Science Laboratory (MSL) was flown twice.

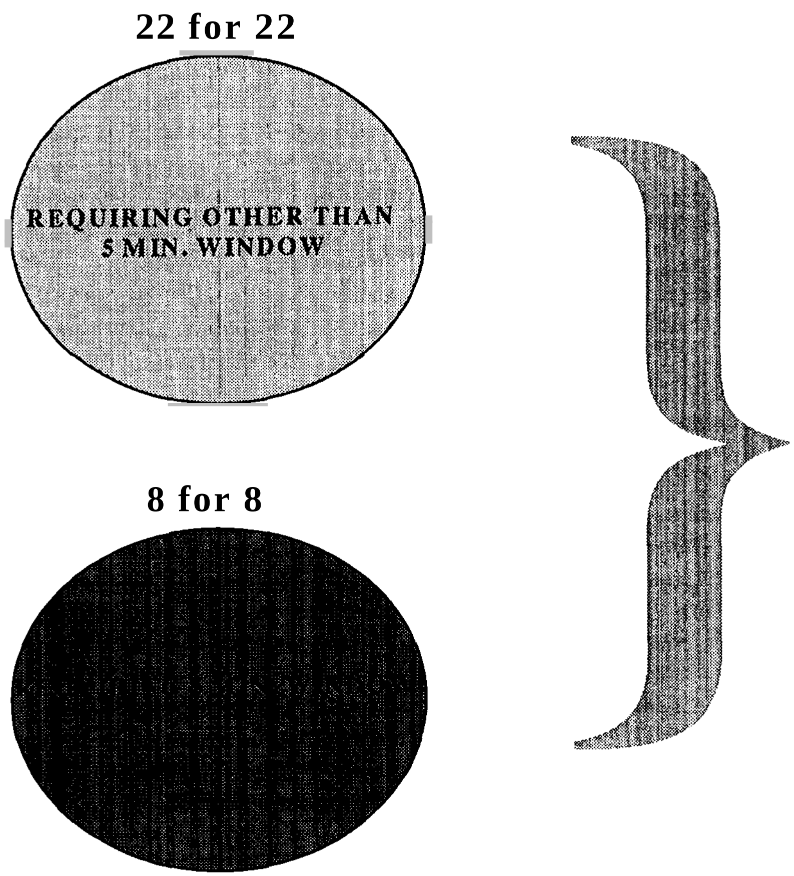
The six flights manifested for FY 1998 include a major microgravity payload, the last Spacelab mission (Neurolab), and two more resupply flights to the Russian Space Station Mir. The Space Shuttle will also make its first assembly flight to the International Space Station. Finally the Space Shuttle plans to deploy the last of the "Great Observatories" when it launches the Advanced X-Ray Astrophysics Facility (AXAF).

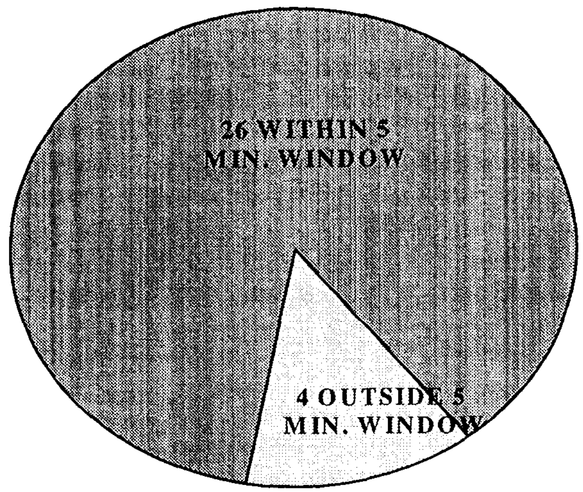
Eight flights will be flown during FY 1999, including six International Space Station assembly flights. In addition, the last two dedicated research missions will be flown; one on Spacehab, and the Shuttle Radar Topography Mission (SRTM), a joint DOD/NASA payload to study the earth.

SHUTTLE LAUNCH HISTORY

30 for 30 LAUNCHES MEETING OUR COMMITMENT

(STS-61 thru STS-87)





STS-64 : Weather in the RTLS area
STS-72 : Computer communication problem
STS-83 : Late tanking & hatch closeout cover
STS-94: Weather at KSC

11/19/97

Payload and Utilization
Operations

HUMAN SPACE FLIGHT

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **PAYLOAD UTILIZATION AND OPERATIONS**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
Spacelab	40.100	11,900	--	HSF 4-3
Payload processing and support	45,900	43,900	39,200	HSF 4-6
Expendable launch vehicle support	[36,900]	[39,000]	31,500	HSF 4-8
Advanced projects	34,700	46,700	10,000	HSF 4-10
Engineering and technical base	144,600	102,900	101,300	HSF 4-18
Total,,	265,300	205,400	182,000	

Distribution of Program Amount bv Installation

	FY 1997	FY 1998	FY 1999
Johnson Space Center	91,221	82,900	48.500
Kennedy Space Center	67,600	47,900	73,600
Marshall Space Flight Center	92,946	47,775	48,800
Stennis Space Center	1,700	1,400	1.500
Ames Research Center	135	--	--
Langley Research Center	500	--	--
Lewis Research Center	299	--	--
Goddard Space Flight Center	7,400	10,700	7,300
Jet Propulsion Laboratory	250	--	--
Headquarters	3,249	14,725	2,300
Total,,	265,300	205,400	182.000

PROGRAM GOALS

The primary goals for the funding requested in Payload Utilization and Operations are to support the processing and flight of shuttle payloads, to ensure maximum return on the research investment, to reduce operations costs, to continue implementing flight and ground systems improvements, and to support strategic investments in advanced technology needed to meet future requirenients.

STRATEGY FOR CHIEVING GOALS

The principal areas of activity in the Payload Utilization and Operations program are: 1) provide safe and efficient payload preparations and launch and landing services while reducing costs of Space Shuttle-related services: 2) provide mission planning, integration and processing for science application missions utilizing Spacelab hardware through the Neurolab mission scheduled for FY 1998; ***3)*** within Advanced Projects, identify and develop advanced technology to support Shuttle, International Space Station (ISS) and future Human Exploration and Development of Space programs to improve safety and reduce costs, promote space commercialization and technology transfer, and manage the agency's Orbital Debris program; and 4) within Engineering and Technical Base (ETB), empower a core workforce to operate Human Space Flight laboratories, technical facilities, and test beds, and stimulate science and technical competence in the United States. The Payload Utilization and Operations budget reflects a commitment to meet a wide array of programs ranging from Spacelab missions, flight hardware development and integration, space flight safety projects. and maintenance of an institutional base from which to perform NASA programs at reduced cost through re-engineering, consolidation and operational efficiency processes.

Beginning in FY 1999, funding for Expendable Launch Vehicle (ELV) mission support will be consolidated in this account. This represents a change for the FY 1998 budget and operating plans where the ELV mission support was funded under Earth Science (formerly Mission to Planet Earth) and Space Science accounts. This action is being taken to align funding and management responsibilities consistent with the decision on transferring management responsibilities to the Office of Space Flight. The consolidation will assign the KSC the operational program management, with the engineering support and technical advice and assistance provided principally by the MSFC. This is expected to result in even greater efficiencies in launch operations support, largely centered around the KSC and the Cape Canaveral Air Force Station in Florida.

BASIS OF FY 1999 FUNDING REQUIREMENT

SPACELAB

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Spacelab	40,100	11,900	

PROGRAM GOALS

Spacelab is a versatile, reusable, cost-effective observatory and laboratory facility located in the Space Shuttle payload bay. Spacelab supports a wide variety of science and technology development experiments which are developed by the utilizing programs within NASA and other external organizations. Spacelab serves as both an observatory and a laboratory, giving scientists the opportunity to conduct a large variety of scientific experiments in the unique environment of space.

STRATEGY FOR ACHIEVING GOALS

Ten foreign nations, including nine members of the European Space Agency (ESA), participated in the joint Spacelab development prograni with NASA. The ESA designed, developed, manufactured and delivered the first set of Spacelab hardware which consisted of a pressurized module, five pallets, subsystem support hardware (e.g. igloo, Instrument Pointing Subsystem (IPS), racks, avionics, computers) and much of the ground support hardware and flight and ground software.

Spacelab is configured within the orbiter bay in numerous ways to accommodate scientific experiments in the unique environment of space. "Hands on" experiments requiring astronaut participation use the pressurized module configuration. Experiments not requiring a pressurized environment, or requiring visual access to space, use the unpressurized pallet configuration. The module is pressurized and thermally controlled to enable astronauts to work in a "shirt sleeve" environment. Easy crew access from the orbiter middeck to the module is enabled by the Spacelab tunnel. Module missions largely consist of life and microgravity sciences experiments.

Spacelab pallet missions are designed to accommodate up to five pallets in the orbiter bay, depending on the experiment requirements. In the event the experiment requires the use of the Spacelab computers and other avionics hardware which must be protected from the space environment, the igloo is used to house the hardware and is flown as an attachment to the pallet. Other pallet configurations include the Spacelab pallet system (SPS). One configuration supports missions requiring the use of the Spacelab computer system and pallet in a mixed cargo configuration (i.e., more than one major payload flown in the orbiter bay rather than a single major payload flown using the igloo subsystem).

Spacelab operations support is comprised of mission planning, mission integration, and flight and ground operations. This includes integration of the flight hardware and software, mission independent crew training, systems operation support, payload operations control support, payload processing, logistical support and sustaining engineering. Support software and procedures development, testing, and training activities are also included in **NASA's** funding request. The Spacelab operations cycle is repealed with each Spacelab flight, but with a different payload complement. This cycle consists of two processing integration steps. Spacelab Level IV processing performs the integration and checkout of the experiment equipment with individual experiment mounting elements like racks, rack sets, and pallet segments, and is funded by the payload sponsor. This activity is normally performed at the Kennedy Space Center (KSC) but is not part of the Spacelab operations budget. Spacelab Level III/II processing then combines and integrates all experiment mounting elements such as racks, rack sets and pallet segments, which have the experiment equipment already installed and ready for checkout with the Spacelab software. This processing activity is also performed at KSC and is funded under the Spacelab budget.

Spacelab operations also funds smaller secondary payloads like the Get-Away Specials (GAS) and Hitchhiker payloads. The GAS payloads are research experiments which are flown in standard canisters that can fit either on the side-wall of the cargo bay or across the bay on the **GAS** bridge. They are the simplest of the small payloads with limited electrical and mechanical interfaces. Approximately 141 GAS payloads have been flown. The Hitchhiker payloads are the more complex of the smaller payloads, and provide opportunities for larger, more sophisticated experiments. The Hitchhiker system employs two carrier configurations: (1) a configuration on the orbiter payload bay side-wall and (2) a configuration across the payload bay using a multi-purpose experiment support structure (MPESS). During the mission, the Hitchhiker payloads can be controlled and data can be received using the aft flight deck computer/standard switch panels or from the ground through the payload operations control center (POCC).

Payload analytical integration is the responsibility of the Payload Projects Office at the Marshall Space Flight Center (MSFC), and is supported by a contract with Boeing. Physical payload integration and processing is the responsibility of the Payload Management and Operations Office at the KSC, and is also supported by a contract with Boeing.

Another item funded in Spacelab operations is the Flight Support System (FSS). The FSS consists of three standard cradles with berthing and pointing systems along with avionics. It is used for on-orbit maintenance, repair, and retrieval of spacecraft. The FSS is used on the Hubble Space Telescope (HST) repair/revisit missions.

The last Spacelab flight is scheduled for early 1998, with the advent of the more permanent science laboratory flown by the International Space Station (ISS).

In FY 1998, Spacelab operations funding for GAS, Hitchhiker payloads and the FSS was transferred to the Payload Processing and Support budget.

MEASURES OF PERFORMANCE

Spacelab Missions	plan	Actual
Microgravity Science Laboratory (MSL-1)	March 1997	April 1997
Microgravity Science Laboratory (MSL-1) Reflight		July 1997
United States Microgravity Payload (USMP-4)	October 1997	November 1997
Space Life Sciences Laboratory-4 (Neurolab)	March 1998	April 1998

	FY 1997		FY 1998		FY 1999
Flight Hardware Utilized	plan	Actual	plan	Revised	plan
Long Module	1	2	1	1	--
Multi-Purpose Experiment Support Structures (MPESS)	--	1	1	1	--
Hitchhiker Experiments	14	13	5	8	4+TBD
Get Away Special Payloads	2+TBD	3	2+TBD	7+TBD	TBD
Contractor Workforce					
KSC (Boeing)	228	186	73	0	0
MSFC (Boeing)	158	135	62	70	0

ACCOMPLISHMENTS AND PLANS

In FY 1997, Development of the Student Experiment Module (SEM) was completed and the first flight of the SEM Pilot Program (SEM-1) was in October 1996. The Spacelab program supported requirements to fly Microgravity Science Laboratory (MSL-1) and MSL-1 reflight missions, 13 Hitchhiker payloads and ***3*** Get Away Special (GAS) payloads were flown. Reimbursable funds of $435,000 were received in FY 1997 to cover processing costs for **GAS** and Hitchhiker payloads.

Regarding FY 1998 activities, The Spacelab program will support requirements and provide the infrastructure to fly the United States Microgravity Payload (USMP-4) and Neurolab missions. Because the Spacelab program is being terminated in FY 1998, the Hitchhiker, GAS, and FSS programs are being transferred to the Payload Carriers and Support program. Following the Neurolab mission, the final Spacelab program phase-down will occur including disposition of hardware and software and closing the high bay in the Operations and Checkout facility at KSC. In FY 1998 and subsequent years, significant reductions in both laboratory support and civil service workforce will occur from discontinuing the Spacelab program.

BASIS OF FY 1999 FUNDING REQUIREMENT

PAYLOAD PROCESSING AND SUPPORT

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Payload processing and support	45,900	43,900	39,200

PROGRAM GOALS

The primary goal for payload processing and support is to provide the capability to safely and efficiently assemble, test, checkout. service, and integrate a wide variety of Space Shuttle spacecraft and space experiments.

STRATEGY FOR ACHIEVING GOALS

The payload processing and support program provides the technical expertise, facilities and capabilities necessary to perform: payload buildup: test and checkout: integration and servicing of multiple payloads; transportation to the launch vehicle; and integration and installation into the launch vehicle. Included in this program are operational efficiencies gained to date, as well as additional anticipated efficiencies to reduce cost and improve customer satisfaction. Efficiencies already in place have reduced processing time and error rate. Due to the termination of the Spacelab program in FY 1998, the Hitchhiker, Get Away Special (GAS) and Flight Support System (FSS) program became part of the Payload Processing and Support program in FY 1998.

MEASURES OF PERFORMANCE

	FY 1997		FY 1998		FY 1999
Missions Supported	plan	Actual	plan	Revised	plan
Space Shuttle Missions	7	8	7	6	8
Spacelab Payloads	1	2	2	1	--
Hitchhiker Experiments	14	**13**	5	6+TBD	4+TBD
Get-Away Special Payloads	2+TBD	**3**	2+TBD	7+TBD	TBD
Mir Missions	**3**	**3**	2	2	1
Other Major Payloads	5	5	5	4	--
Other Secondary Payloads	--	--	--	21	TBD
Expendable Launch Payloads	10	4	8	8	8
Number of Payload Facilities Operating at KSC	**6**	6	**6**	6	**6**
KSC Payload Ground Operations (PGOC) Workforce	**360**	**330**	**360**	**366**	**312**

ACCOMPLISHMENTS AND PLANS

The FY 1997 funding provided payload processing and support for eight Space Shuttle missions, as well as the necessary customer payload processing facilities and support for over 26 major and secondary payloads. Among the payloads processed in FY 1997 include the first flight of the Student Experiment Module (SEM) Pilot Program (SEM-1) in October 1996. The Spacelab program supported requirements to fly Microgravity Science Laboratory (MSL-1) and MSL-1 reflight missions, 13 Hitchhiker payloads and 3 Get Away Special (GAS) payloads were flown. Because the Spacelab program is being terminated in FY 1998, the Hitchhiker, GAS and FSS programs are being transferred to the Payload Processing and Support program. In FY 1998 and subsequent years, significant reductions in both laboratory support and civil service workforce will occur from discontinuing the Spacelab program.

In FY 1998, Payload Processing and Support will provide launch and landing payload support activities for six Space Shuttle missions and payload processing support and facilities used for nine manifested major payloads, including the last two Spacehab missions to Mir and one ISS flight (first element launch). Over 25 manifested payloads will be supported, including U.S. Microgravity payload (USMP-4), Neurolab, Spartan 201-04, Advanced X-Ray Astrophysics Facility (AXAF), Shuttle Mir missions ((S)MM-8, 9), Alpha Magnetic Spectrometer (AMS), two International Space Station (ISS-01-2A, 02-3A) assembly flights, and several secondary payloads. Reimbursable funds of $505,000 are expected to be received in FY 1998 to cover processing costs for GAS and Hitchhiker payloads. Payload processing facility support will be provided to ELV payloads such as TRACE, LANDSAT 7, Deep Space-1, EOS-AM1, Cassini, and NOAA-K. Plans are to deactivate the Spacecraft Assembly and Encapsulation Facility at the end of FY 1998.

In FY 1999, Payload Carriers and Support will provide launch and landing payload support activities for eight Space Shuttle missions, including the HOST, Shuttle Radar Topography Mission (SRTM) and STS-95 (a "science transition mission" Spacehab flight): and payload processing support and facilities for ten manifested major payloads, including six ISS flights (planned assembly missions 2-7). A number of secondary payloads will also be supported. Payload processing facility support will be provided to ELV payloads such as WIRE, SWAS, GOES-L and TDRS F-8.

BASIS OF FY 1999 FUNDING REQUIREMENT

EXPENDABLE LAUNCH VEHICLE SUPPORT

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Expendable Launch Vehicle Support	[36,900]	[39,000]	31,500

PROGRAM GOALS

The goals of the Expendable Launch Vehicle (ELV) mission support will be to enhance probability of mission success and on-time cost effective launch services for NASA missions undertaken in support of NASA's strategic plan through a core of high quality technical experts in launch service acquisition **and** management for all classes of expendable launch vehicles, to provide comprehensive advanced mission analysis and feasibility assessments for NASA payload customers, to increase efficiency in launch site operations and countdown management, and to provide low cost secondary payload opportunities.

STRATEGY FOR ACHIEVING GOALS

NASA has consolidated ELV management and acquisition of launch services at Kennedy Space Center (KSC). Effective in FY 1999, all funding for mission support will likewise be transitioned from the Office of Space Science and the Office of Mission to Planet Earth within the Office of Space Flight, consistent with assignment of responsibility for ELV management to OSF.

KSC is responsible for acquiring requisite launch services to meet all Enterprise requirements and to increase the probability of mission success through focused technical insight of commercially provided launch services. This technical management is performed by a core team of civil servants and contractor support located, primarily at KSC. KSC personnel are also resident at key launch sites, launch facilities and customer facilities. NASA personnel are resident at Vandenberg AFB in California where all launches into a polar orbit, such as those required by the Mission to Planet Earth Enterprise, are conducted. Resident office personnel are located in launch service contractor plants, specifically The Lockheed Martin Corporation Atlas Centaur plant in Denver and the Boeing Corporation Delta plant in Huntington Beach, California. KSC customer offices are being established at GSFC and JPL as the centers assigned program management responsibility for the majority of Space Science and Earth Science missions requiring access to space via NASA-provided launch services.

Advanced mission design/analysis and leading edge integration services are provided for the full range of NASA missions under consideration for launch on ELVs. Technical launch vehicle support is provided in the development and evaluation of spacecraft Announcement of Opportunities, to enable cost effective consideration of launch service options and technical compatibility. Early definition of vehicle requirements enables smooth transition to launch service and an excellent cost containment strategy.

Launch site operations and countdown management is being improved through the use of a consolidated launch team, efficient telemetry systems, and close partnership with Boeing and USAF to assure lowest cost west coast Delta launch complex operations.

NASA's ELV secondary payload program enables efficient use of excess vehicle performance on selected NASA, USAF and commercial missions through funding integration of small secondary payloads. The secondary payloads come from university research institutions and often international cooperatives which can afford the constraints of this unique option, which is to take advantage of available limited excess space and performance from a primary payload and accept it's launch schedule and orbit. NASA has developed a standard Delta secondary launch vehicle capability and has similar discussions under way with other US ELV providers.

MEASURES OF PERFORMANCE

Metric	FY 1997 Plan	FY 1997 Actual	FY 1998 plan	FY 1998 Revised	FY 1999 plan
Number of ELV Mission Supported	10	5	8	8	11

ACCOMPLISHMENTS AND PLANS

During FY 1997 five NASA-managed ELV launches were conducted, four were successful. These included the three successful Delta launches of the Mars Global Surveyor, the Mars Pathfinder and the Advanced Composition Explorer and the Atlas-Centaur launch of the NOAA GOES spacecraft. The Orbital Sciences Corporation (OSC) Pegasus launch vehicle failed to successfully separate the SAC-B and HETE payloads into a useful orbit. Three Pegasus missions were deferred from FY 97 to FY 98 launch due to OSC Pegasus manifest delays following the SAC-B/HETE failure in late 1996: SNOE, TERRIERS and SWAS. The NOAA POES K mission was deferred to launch in FY 98 by NOAA , it is a call-up mission and the health of the constellation allowed NOAA to defer launch until FY 98. The last mission is the piggyback launch of two NASA-sponsored international cooperatives Danish Orsted and South African SUNSAT missions flying on USAF Argos mission aboard a Delta launch vehicle. The USAF primary payload continues to have spacecraft readiness problems resulting in continued delay to these payloads, which were originally planned and ready for launch in the sumnier of 1995.

During FY 1998, eight ELV launches and one secondary ELV mission are planned. The Cassini mission was successfully launched on October 15, 1997 using a USAF-provided Titan IV Centaur launch vehicle. Three Pegasus launches are planned along with two Delta, one Titan II provided by the USAF; and the first launch of an Atlas-Centaur from a new launch site at Vandenberg. NASA has worked closely with the USAF and Lockheed Martin Corporation, provider of the Atlas IIAS launch service, to conduct pathfinder operations at the newly constructed west coast Atlas launch pad. KSC also plans to award multiple Small ELV launch services (SELV II) contracts during FY 1998 to assure access to space for NASA small explorer (SMEX) and earth system science probes (ESSP) class of payloads.

Eleven NASA-managed ELV launches are planned in FY 1999. These include three Pegasus launches, five Delta launches, one USAF-provided Titan II launch and two Atlas-Centaur launches. Two secondary payloads are also planned for launch. KSC plans to award a launch services contract for medium-class ELV (MELV II) services to meet payload requirements for Discovery and MIDEX type missions in FY 1999.

BASIS OF FY 1999 FUNDING REQUIREMENT

ADVANCED PROJECTS

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Advanced projects	34,700	46,700	10,000

PROGRAM GOALS

The primary goals of the program are to mature technologies to enhance crew safety for the Space Shuttle and Space Station, to implement flight and ground systems improvements to substantially reduce cost of Space Flight operations, and to pursue advanced technology developments to meet future Human Space Flight requirements. Secondary goals of the program are to promote transfer of advanced technologies and to develop a fully capable, diverse and motivated workforce. The Advanced Projects activity includes six program elements: Systems Analysis, Advanced Technology Development, Advanced Space Systems, X-38 demonstration program, Telerobotics Research and Technology, and the Advanced Extravehicular Activity (EVA) Systems.

In order *to* apply its resources to only the agency's highest priorities, NASA is terminating or completing most of the ongoing Advanced Projects, with the exception of the X-38 Project. Termination/orderly completion of Advanced Projects should be completed by the end of FY 1998. Advanced project activities related to the Mars Surveyor mission will be provided for within the Office of Space Science's Mars Surveyor Program (MSP). This collaborative effort between the Office of Space Flight, the Office of Life and Microgravity Sciences and Applications, and the Office of Space Science will be initiated in FY 1998 and will include radiation and soil/dust measuring devices and an in-situ propellant production experiment on the robotic missions to Mars. The scientific data gathered from these missions will be critical for achieving the goals of the Human Exploration and Development of Space Enterprise.

STRATEGY FOR ACHIEVING GOALS

The Advanced Development and Operations program supports projects which improve ground and flight operations of current and future Human Space Flight vehicles by identifying, advocating and demonstrating available technologies and processes which are more efficient, cost-effective, reliable, have dual use potential, and meet safety and performance requirements. The projects are developed to a prototype level to validate their objectives within three years. Successfully demonstrated projects are transitioned to an operational program for implementation and to private enterprise for commercial development.

The Advanced Space Systems program includes the Orbital Debris program and a series of flight demonstration experiments to validate critical advanced technologies in a relevant environment. The Orbital Debris effort supports projects which improve the safety of the Space Shuttle and the Space Station by measuring, modeling, and mitigating the orbital debris environment. In addition, the Orbital Debris activity includes an international cooperative program, jointly funded by the space agencies of Russia, Japan, China and the European Space Agency, which seeks to develop a common understanding of the debris environment. This program also develops common practices for protecting spacecraft and mitigating the orbital debris environment. The Flight Demonstration program identifies and demonstrates available technologies and processes which are efficient, cost-effective, reliable, and meet safety and performance requirements. Projects are matured to a protoflight level, utilizing existing carriers as test beds for developing space flight hardware and operational processes to ensure their readiness to meet operational requirements. Flight demonstrations also include training for young NASA engineers and managers with early "hands-on" flight hardware experience.

For safety reasons, a Crew Return Vehicle (CRV) is necessary for permanent human habitation of the International Space Station. The Russian Soyuz spacecraft will provide an interim crew return vehicle capability during the 3-crew member stage. The X-38 experimental vehicle is specifically designed to demonstrate the technologies and processes required to produce a CRV in a "better, faster, cheaper" mode. Evaluations of the performance of the technologies of the X-38 systems are conducted through a series of ground, air, and space tests. The X-38 is based on the U.S. Air Force/Martin-Marietta X-24A lifting body research vehicle. Successful demonstration of the X-38 technologies is a precursor to the decision process to select a long-term CRV configuration for the International Space Station. Through cooperative arrangements which are under discussion with the European Space Agency, the DOD, and the Japanese Space Agency, NASA also seeks to find and develop commonality among space vehicles being developed for CRV and other requirements. ***An*** independent study will be initiated in FY 1998 to assess the applicability of the X-38 design for the Space Station CRV, as well as a Crew Transfer Vehicle (CTV) and other options which meet the Space Station's crew rescue requirements. This study will inform the industry-led Future Space Launch trade studies described in the Aeronautics and Space Transportation Technology section.

The primary goals of the Advanced EVA program are to perform the scientific research and engineering development needed to mature technologies that enhance EVA crew safety, reduce EVA operational cost and enhance capabilities to meet future space flight requirements. The Advanced EVA research and development program includes research and development to reduce the operational impact of decompression sickness, while increasing safety via better understanding of the science involved. The research and development roadmap includes tasks to address environmental protection, EVA mobility, electronics integration, and EVA system integration with other space systems. The Advanced EVA program is conducted using a mix of ground based simulation and flight testing to prove the developnient approach. After four years of ground-based research and development, the program concludes with a three-year task to demonstrate on-orbit the new EVA technologies from a systems point of view. The program actively seeks partnering with industry and other government agencies as well as transfer of technology into the prograni from outside sources to accomplish the needed technology development.

The Telerobotics Research and Technology program includes research and development of telerobotics technologies to improve crew efficiencies and capabilities for the Human Exploration and Development of Space, including the International Space Station and Space Shuttle. Telerobotics research includes areas such as EVA assistant, dexterous manipulators, sensing and processing, mobility systems, human interfaces, and other related telerobotics technologies. The telerobotics program is conducted through ground and flight research and demonstrations to prove the viability of each technology approach. The Telerobotics Research and Technology program was transferred to the Advanced Projects Office during FY 1997, from the former Office of Space Access and Technology.

MEASURES OF PERFORMANCE

The success of the Advanced Projects activities has been measured by the success of its projects. Over 100 projects have been supported in the past six years, most of which have been successful in delivering products that enhance the efficiency and reduce the cost of ground and flight operations. Many of the advanced technologies incorporated in the new integrated Shuttle/Station Mission Control Center were developed in this program. These technologies are contributing to a significant reduction of Office of Space Flight mission operations costs.

In the Orbital Debris activity, accurate measurements have been made of the orbital debris environment. Models have been developed to predict the changes in the environment as a function of time. Utilizing these measurements, flight rules, operational procedures, and new orbital debris protection systems have been developed and/or modified to improve/enhance safety during Shuttle and Space Station operations. The following events represent significant milestones in the successful completion of this program:

Advanced Space Systems

International Space Welding Experiment (ISWE) Cargo Integration Review Plan: 1st Qtr FY 1997 Revised: Under review	The ISWE will demonstrate the ability to perform contingency repairs to the International Space Station using an electron beam welding device developed by the Paton Institute in the Ukraine.
Orbital Debris Collector (ODC) Returned from Mir Plan: 4th Qtr FY 1997 Actual: 1st Qtr FY 1998	The ODC is an experiment to collect *in-situ* samples of the micro debris environment from the orbit of the International Space Station to understand the sources of this debris and thus enabling effective steps to mitigate it.
Students for the Exploration and Development of Space Satellite (SEDSAT) Delivery to KSC Plan: 4th Qtr FY 1997 Actual: 4th Qtr FY 1997	Delivery of SEDSAT satellite for testing and integration
Students for the Exploration and Development of Space Satellite (SEDSAT) Launch Plan: 41h Qtr FY 1997 Actual: 3rd Qtr FY 1998	Deployment of SEDSAT as a DELTA II secondary payload. SEDSAT will serve as an amateur radio relay system and will collect multi-spectral remote sensing data. This deployment has been delayed because the payload has been re-manifested from the Shuttle to a Delta expendable launch vehicle.

Static Feed Electrolyzer (SFE) Flight Demonstration Plan: 1st Qtr FY 1998 Revised: Under Review	This flight demonstration was to verify the performance capability of the SFE subsystem in microgravity during the STS-87 mission. This flight demonstration was redirected at the request of Space Station. **A** new oxygen generation experiment is planned.
International Space Welding Experiment (ISWE) Flight Demonstration Plan: 1st Qtr FY 1998 Revised: Under Development	The capability of the Ukrainian Universal Hardware to perform contingency repairs on the International Space Station will be demonstrated during the STS-87 Mission. The ISWE project has been recently de-manifested to accommodate the reflight of the EVA Development Flight Test (EDFT) program on STS-87. **An** alternative flight manifest opportunity for ISWE is under review.

X-38

Atmospheric Test Program Plan: 4th Qtr FY 1997 Revised: 4th Qtr FY 1998	Five atmospheric test flights of Vehicles 131 and 132 conducted to demonstrate full lifting body control and parafoil control systems. This milestone has been delayed due to difficulties in parafoil testing.
Begin initial Space Vehicle (201) Construction Plan: 4th Qtr FY 1997 Actual: 4th Qtr FY 1997	Construction of the first (201) space vehicle will be initiated. Primary structure (cabin and aft fuselage) will be fabricated, most subsystems installed and ready for integrated lest, and some aeroshell panels with thermal protection system will be completed.
Award contract for de-orbit module Plan: 2nd Qtr FY 1998	Purchase of de-orbit module for **X-38** orbital flight test
CRV Formulation Study Plan: 3rd Qtr FY 1998	Initiate independent assessment regarding the applicability of the X-38 design for the CRV
Flight test for the third atmospheric vehicle Plan: 4th Qtr FY 1999	Additional testing will be conducted to demonstrate full lifting body control, using the sub-scale vehicle with final shape.

Advanced EVA Research and Development

Gloves ready for flight tests Plan: 2”“Qtr FY 1997, 3rd Qtr FY 1998 & 3rd Qtr FY 1999 Actual: 2nd Qtr FY 1997	Demonstrates on-orbit perfomiance of gloves which incorporate increased mobility features and better thermal protection.
Soft space suit configuration hardware delivery Plan: 2nd Qtr FY 1998	Delivery of new soft space suit for testing. Soft suits hold potential of being lighter weight and easier to stow.
Soft space suit configuration comparison test delivery Plan: 3rd Qtr FY 1998	Demonstrates the amount of mobility that can be incorporated into a soft suit configuration.
Radiator ready for test Plan: 3rd Qtr FY 1998	Demonstrates on-orbit cooling using a radiator instead of water sublimation in the real thermal environment,

Telerobotics Research and Technology

Free-Flying Camera Robots for EVA Plan: 4th Qtr FY 1997 Actual: 1st Qtr FY 1998	Implement upgrades to the existing Supplemental Camera and Maneuvering Platforni (SCAMP) system.
Robotics Technologies for ISS Maintenance	
Plan: 2””Qtr FY 1997	Testing of remote surface inspection systems.
Plan: 4th Qtr FY 1997	Evaluation of calibrated synthetic viewing.
Plan: 4th Qtr FY 1997	Performance of robotic control technologies.
Actual: 4th Qtr FY 1997	

ACCOMPLISHMENTS AND PLANS

The X-38 program continued to measure subsystem and system performance throughout FY 1997. A key element of the plans included completion of the Atmospheric Test program in which two vehicles (131, 132) were drop-tested from a B-52 to prove a mix of lifting body and parafoil systems and flight modes. A third sub-scale atmospheric test vehicle with the identical shape of the operational vehicle will be added the X-38 program in FY 1998. Flight tests for the third atmospheric vehicle are scheduled for FY 1999. The second space test vehicle will be started in FY 1999 with a completion date of FY 2000. The Aft Fuselage, Outer Skin and Thermal Protection Systems (TPS) were completed and the first de-orbit module was delivered. Integrated testing of vehicle 201 will also begin in FY 1998. In FY 1998, an independent study will be initiated to determine the applicability of the X-38 design for the Space Station Crew Return Vehicle and other options.

The second phase (hardware development phase) of the International Space Welding Experiment (ISWE) with the Paton welding Institute (PWI) in Ukraine was successfully initiated. A phase 2 (hardware development) contract with PWI was negotiated for the delivery of two sets of universal hardware as well as a work station. Design and fabrication of the flight universal hardware and the work station were completed early in FY 1997. Delivery of the flight universal hardware occurred in FY 1996 and the flight workstation was completed in early FY 1997.

The Orbital Debris program is directed at measuring the orbital debris environment, developing debris growth mitigation measures, and enhancing spacecraft protection and survivability techniques. In FY 1998-99, additional measurements of the environment were obtained from numerous Shuttle missions providing invaluable data on the nature of the micro-debris environment and its damage potential to manned spacecraft. The liquid metal mirror telescope was moved to Cloudcroft, New Mexico. Visual observations of debris particles as small as 10 centimeters in geostationary orbit are possible using this telescope. The Orbital Debris Radar Calibration Spheres (ODERACS-2) flight demonstration was flown on the Space Shuttle. ODERACS-2 successfully deployed three spheres and three dipoles which were used to calibrate the Haystack Orbital Debris Radar, optical telescopes and other radar used to characterized the orbital debris environment.

In FY 1997 and FY 1998, the Haystack Auxiliary Radar and the Haystack Radar will continue to monitor the orbital debris environment for the Space Station. Orbital debris will continue to focus on characterizing changes in the orbital debris environment as a function of time and on establishing measures for mitigation of debris growth trends. An international geostationary debris observing program will be initiated with participation from NASA, ESA, Russia, Japan, Australia, and other spacefaring nations. Work will begin on the design of an Extra Vehicular Activity (EVA) debris shield for protecting the Space Station crews when they are exposed to the debris environment during an EVA.

In FY 1997, Advanced Projects supported the AERcam/Sprint flight experiment, a robotic "flying eye" for visualization and inspection of science and Space Station payloads. The Debris Capture experiment was returned from the Mir station after approximately one year in orbit. Analysis will begin of the debris samples captured by the aero gel. The ISWE flight demonstration will acheive launch readiness early in FY 1998, but a flight date aboard the Space Shuttle remains to be determined.

In FY 1997 and FY 1998, the Advanced EVA Research and Development program will start research to address the mechanisms which control decompression sickness in a zero gravity environment. Research into better protection for EVA operations in the space environment will also be initiated. The design efforts for space suits which are predominantly built with soft elements and a portable life support system which uses cryogenic oxygen will be initiated.

As previously noted, by the end of FY 1998, ongoing Advanced Projects, other than the **X-38** program, will be terminated or completed.

BASIS OF FY 1999 FUNDING REQUIREMENT

ENGINEERING AND TECHNICAL BASE

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Engineering and technical base	144,600	102,900	101,300

PROGRAM GOALS

The focus of the Engineering and Technical Base (ETB) is to support the institutional capability in the operation of space flight laboratories, technical facilities, and testbeds; to conduct independent safety, and reliability assessments; and to stimulate science and technical competence in the United States. ETB activities are carried out at the Johnson Space Center (JSC) including White Sands Test Facility (WSTF), Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC), and Stennis Space Center (SSC). ETB provides the underpinning of the Centers' performance of research and analysis and testing tasks, to solve present problems, and to reduce costs in developing programs, technologies, and materials.

STRATEGY FOR ACHIEVING GOALS

The complex and technically challenging programs managed by the Office of Space Flight (OSF), now and in the future, are most effectively carried out by sustaining a NASA "core" institutional technical base. It is vital to preserve essential competency and excellence. Since FY 1994, the OSF centers have consolidated activities and have identified ways to economize the resources comniitted to ETB while maintaining ETB's benefits to the nation's human space flight program. Over the next few years, this consolidation will continue to generate savings in information resources management and contract streamlining. A prioritized core environment will be dedicated to multi-program labs and test facilities, associated systems, equipment, and a full range of skills capable of response to research, testing and simulation demands.

As the ETB budget is reduced, several activities will be continued to refine current business practices. Mandatory equipment repair and replacement will be reassessed. Software applications for multi-program analytical tools will be implemented. The strategy to better manage the NASA investment in information processing resources includes aggressive actions to integrate and consolidate more ADP operations. ETB will ensure synergism among major NASA engineering programs. Awards for education and research tasks will be granted to support educational excellence and research learning opportunities in colleges and universities. A key challenge of the ETB strategy will be to provide a core capability for future human space flight endeavors with fewer resources. Future budget constraints dictate that new innovative processes be adopted to meet critical ETB core requirements, and that non-critical capabilities be streamlined or eliminated.

MEASURES OF PERFORMANCE

Laboratories & facilities supported (KSC)	Maintains 7 science and engineering laboratories in support of 6 agency programs
Laboratories & facilities supported (JSC)	Maintains 156 science and engineering laboratories in support of 52 agency programs
Laboratories & facilities supported (MSFC)	Maintains science and engineering laboratories (7) and facilities (1 16) in support of 42 agency programs
Laboratories & facilities supported (SSC)	Maintains *3* science and engineering laboratories in support of 2 agency programs
Inforniation resource management (IRM) Five Year Investment Plan (MSFC) Plan: 4th Qtr FY 1996 Revised: 2nd Qtr FY 1998	Consolidate Management and Operations of the other Field Centers to the supercomputer Arnes Research Center is in charge of the initiative. A draft schedule is currently being reviewed, but this will be an on-going effort through FY 1998.
NASA Minority University Research and Education Program at JSC, KSC, MSFC & SSC	Award education and research grants

ACCOMPLISHMENTS AND PLANS

The institutional technical base accomplished numerous activities in FY 1997. At JSC, ETB funded the purchase of laboratory equipment and technicians, engineering workstations, calibration equipment and services, component fabrication, and Class VI computer maintenance and operations in support of the science and engineering laboratories and facilities at JSC. This ETB support ensures that JSC retains the capability to perform real-time mission analysis of flight anomalies and real-time and post-flight problem resolutions, as well as other science and engineering testing and analysis. In addition to laboratory support, ETB supports safety, reliability, and quality assurance (SR&QA) activities for the Space Shuttle and Space Station programs.

In FY 1997, JSC used the majority of its ETB funding to maintain the science and engineering laboratory capability to perform real-time mission analysis of flight anomalies, real-time and post-flight problem resolutions, as well as other testing and analysis. For example, ETB funding was used to complete the upgrade WSTF Test Stand 401 for non-toxic propellants to support Shuttle engine development using fuels such as RP-1, ethanol, GOX, and LOX. ETB was also used for the long-lead procurement of a 5-axis milling machine, enabling JSC to meet fabrication requirements for **X-38** project as well as support other in-house engineering projects. JSC also continued to provide Shuttle and Station SRM&QA support and network server upgrades to provide adequate computing capability to science and engineering laboratories and workstations.

At WSTF, FY 1997 ETB funding supported the propulsion testing facility and other laboratory infrastructure. Maintaining this core environment with ETB objectives enabled WSTF to support a customer base with testing and evaluations of spacecraft materials, components, and propulsion systems for safe human exploration and utilization of space. It enabled WSTF to perform tasks for all NASA programs, as well as other Government agencies and the aerospace and medical industry on a reimbursable basis.

At KSC, ETB funding supported the core operational and maintenance capabilities for key science and engineering laboratories; technical operations laboratories including calibrations and standards, non-destructive evaluation and component sampling and ‘analysis; and CAD/CAE engineering services. The ETB budget enables KSC to eliminate potentially critical failures on the KSC fiber optic circuits and assists the Shuttle Launch Processing System organization in understanding and properly using the fiber optics for launch processing. ETB funds provided support to the radiological examination (computed topography) of NASA crystal growth experiments, and supported upgrades to the LC-39 measurement system. Funding also supported participated in the development of landing aids for a lightning warning and prediction system, as well as development of toxic vapor detectors and sensors to measure vapors from the Space Shuttle tile waterproofing compound. Additionally, KSC continued to fund education activities including grants to HBCU/OMU's and the Education Resource Laboratory.

The MSFC allocation of ETB funds supports approximately 50 core laboratory areas. ETB support enables the Center's technical core capability to provide in-depth technical support for designs, developments, testing, mission operations and evaluation of Launch Vehicles, Space Transportation Systems, Space Stations, and Payloads. ETB enables MSFC to conduct research and development efforts related to advanced propulsion systems and spacecraft, as well as engineering design, systems engineering, systems integration, material and process engineering, physical science research, test and evaluation, data analysis and system simulations. As the NASA Center of Excellence in propulsion systems, in FY 1997, MSFC is continuing to support the Advanced Space Transportation Technology Program, whose ultimate objective is to make dramatic reductions in the cost of boosting payloads into low-Earth orbit. Funding in the amount of $12.0 million is identified to continue development of low-cost, small booster technologies and demonstration of rocket-based combined cycle (RBCC) propulsion hardware. Effort on low-cost small booster technologies will include avionics hardware, engine component hardware (injector, chamber, turbomachinery, valves, actuators, ducts and lines), test support and propellants for component testing. RBCC activities include test hardware fabrication, test support and propellants. Funding responsibility for these activities after FY 1997 has been transferred to the Aeronautics and Space Transportation Technology program.

At SSC, ETB supports the SSC technical core laboratory operations. The SSC laboratories perform activities for the Space Shuttle program, reimbursable resident governmental agencies and the CTF test operations. The SSC core laboratory environment provides customers with gas and material analysis, non-destructive evaluations, standards and calibrations and environmental analysis. ETB also enables SSC to complete advanced planning studies involving cost trade presentations for future facility utilization and technology development tasks such as the seal configuration tester prototype. ETB also funds sensor development for engine health management and for spectral analysis.

The ETB program includes the institutional Safety and Mission Assurance (SRM&QA) contractor workforce performs space flight activities at JSC, WSTF, MSFC. This workforce includes highly skilled personnel who are charged with responsibility to conduct assessments of conformance to reliability and quality standards. Surveillance of design, manufacturing and testing of hardware and software was conducted to ensure compliance with NASA safety and mission assurance requirements. The ETB resources will support independent assessments of flight and test equipment and testing operations, including product assurance tasks for the International Space Station program (ISS). However, product assurance tasks and funding for the ISS are being transferred to the Office of Safety and Mission Assurance in FY 1998.

Information resource management (IRM) processing achieved efficiencies and improved economies of scale through the consolidation of IBM-compatible mainframes supporting administrative and programmatic automated data processing (ADP)services at the NASA ADP Consolidation Center located at MSFC. Consolidation of user requirements and information technology plans were iniplemented at JSC, MSFC, SSC and Headquarters. The NASA Automated Data Processing (ADP) Consolidation Center (NACC) provides supercomputing capability for its customers for engineering and scientific computer-intensive applications 7 days a week. The NACC supercomputing facility was established in FY 1994 and is managed through the MSFC NACC Project Office. The NACC supercomputing facility includes a mainframe located at MSFC and a snialler distributed system located at JSC.

The NACC supercomputing customers are from JSC and MSFC. The NACC supercomputer facilities include hardware and software to conduct thermal radiation analyses, computational fluid dynamics, structural dynamics and stress analyses for NASA programs such as the Space Shuttle, X-33, X-34, Space Station, and Reusable Launch Vehicle. The facilities also conduct certification arid engineering performance evaluation of flight and test data.

In cooperation with the goals of the NASA Minority University Research and Education Program. ETB enables the space flight Centers to participate in programs to stimulate science and technical competence in the Nation. The ETB program enabled the Centers to award education and research grants to Historically Black Colleges and Universities (HBCU), Other Minority Universities (OMU),Teacher/Faculty enhancement programs. MSFC awarded a total of 52 grants in FY 1996. Examples of awards granted include solution crystal growth in low gravity; organic fiber optic sensors; hydrazine solution disposal; atmospheric corrosion sensor: properties of ion beam deposits, and phytoalexins in plant disease.

During FY 1998, JSC's Safety, Reliability, and Quality Assurance Directorate and the Shuttle Program will be examining the Shuttle SRM&QA functions supported by ETB. This continues the reengineering of SR&QA as directed during the zero-base review. The decreasing FY 1998 and FY 1999 ETB funding levels will require some Shuttle SRM&QA functions to be transitioned to the SFOC contractor, while other functions will be reduced or eliminated. In addition, JSC is also reducing support of science and engineering laboratories and workstations, resulting in deferment of equipment replacements and procurements and transfer of some testing costs to programs and customers. Also, the Station Independent Assessment effort supported by ETB in FY 1997 and prior years will be transferred with the funding to Code Q for management in FY 1998.

In FY 1998, the ETB budget will continue to implement reductions resulting from the Agency's zero-base review. These reductions will result in a reduced level of science and engineering lab support to human space flight programs, streamlined technical operations, additional ADP consolidation activities, and reduced education and research awards funding. These reductions will require that all Centers continue to assess their range of workforce skills, analytical tools and facilities dedicated to ensure space flight institutional engineering support for future human space flight programs and the existing customer base. This assessment will focus on maintaining core support for design, development, test and evaluations, independent assessments, simulation, operations support, anomaly resolution, and systems engineering activities with reduced funding. The operation and maintenance of the CTF will be supported, as will a variety of research and engineering laboratories. FY 1998 funding is significantly reduced from previous years due to the transfer of the development of low-cost small booster technologies and demonstration of rocket-based combined cycle (RBCC) hardware to the Advanced Space Transportation Technology program; the transfer of the International Space Station independent assessment function to the Office of Safety and Mission Assurance: and other infrastructure reductions at the Human Space Flight Centers.

In FY 1998, the ETB budget continues to support the SSC technical core laboratory operations.

In FY 1999, ETB will continue to conduct business in the current mode, but will be preparing for implementation of the agency's full-cost initiative, planned to begin in FY 2000. Under full-cost, ECTB activities will be planned, justified and budgeted within the benefiting customer receiving the service. All Human Space Flight Centers will be planning future ETB activities around this concept, with the ETB budget as a separate entity being phased out.

In FY 1999, JSC will be preparing to transition its institutional operations to full cost. This includes realignment of ETB funded content in accordance with the full cost directives. JSC will be refining the fabrication and calibration service pool pricing to recover operating costs formerly funded by ETB. JSC will also be working on the transition of full funding responsibility of the Shuttle SRM&QA effort to the Shuttle Program. As preparations for transition to full cost operations are occurring, JSC and WSTF will continue science and engineering laboratory support and Shuttle SRM&QA operations within the FY 1999 ETB funding levels.

In FY 1999, KSC will continue to achieve Zero Base Review (ZBR)-recommended reductions in FY 1999 by reengineering CAD/CAE services including migration to PC platform and elimination of VAX mainframe/software and associated maintenance. The MSFC and SSC will continue institutional support to its lead and performing center roles, while continuing to strive for institutional efficiencies and reductions in their methods of doing business.

In FY 1999, the ETB budget **will** continue to support the SSC technical core laboratory operations.

In FY 1999, MSFC will make the final lease payment on the Engineering Analysis Data System II (EADSII) Cray Triton. ETB funding will only be required to support operations and maintenance costs which are reflected in the MSFC ETB budget. MSFC will also continue evaluate the center's ETB content for determination of how ETB funds will be distributed in a full cost budget environment. This includes developing and defining service pool rates for the Science and Engineering Service Pool and the Information Systems Service Pool.

Science, Aeronautics and Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1999 ESTIMATES

GENERAL STATEMENT

GOAL STATEMENT

The Science, Aeronautics and Technology appropriation provides funding for the research and development activities of NASA. This includes funds to extend our knowledge of the Earth, its space environment, and the universe: and to invest in new aeronautics and advanced space transportation technologies which support the development and application of technologies critical to the economic, scientific and technical competitiveness of the United States.

STRATEGY FOR ACHIEVING GOALS

Funding included in the Science, Aeronautics and Technology appropriation supports the program elements of NASA's four Enterprises:

Human Exploration of Space - uses the microgravity environment of space to conduct basic and applied research to understand the effect of gravity on living systems and to conduct research in the areas of fluid physics, materials science and biotechnology.

Space Science - seeks to answer fundamental questions concerning the galaxy and the universe: the connection between the Sun, Earth and heliosphere: the origin and evolution of planetary systems; and, the origin and distribution of life in the universe.

Earth Science - to understand the total Earth system and the effects of natural and human-induced changes on the global environment.

Aeronautics and Space Transportation Technology - to pioneer high-payoff, critical technologies with effective transfer of design tools and technology products to industry and government.

Funding is also included to provide highly reliable, cost effective telecommunications services in support of NASA's science and aeronautics programs, and to conduct NASA's Agencywide university, minority university, and elementary and secondary school programs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL *YEAR* 1999 ESTIMATES
(IN MILLIONS OF REAL *YEAR* DOLLARS)

	BUDGET PLAN		
	FY 1997	FY 1998	FY 1999
SCIENCE, AERONAUTICS AND TECHNOLOGY	**5,453.1***	**5,552.0****	**5,457.4**
SPACE SCIENCE	1969.3	1983.8	2058.4
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	243.7	214.2	242.0
EARTH SCIENCE	1,361.6	1,367.3	1,372.0
AERONAUTICS AND SPACE TRANSPORTATION TECHNOLOGY	1339.5	1,470.9	1,305.0
MISSION COMMUNICATION SERVICES	418.6	395.8	380.0
ACADEMIC PROGRAMS	120.4	120.0	100.0

* FY 1997 estimates reflect the "pro forma" restatement of Space Station Research Facilities funded in the Science, Aeronautics and Technology appropriation. This restatement is provided for comparability purposes.

** FY 1998 estimates reflect the effects of transferring funds from the enacted levels in P.L. 105-65 for the Mission Support (MS) and Science, Aeronautics and Technology (SAT) appropriations to the Human Space Flight (HSF) appropriation. A legislative proposal is being submitted for the purpose of providing transfer authority between the HSF appropriation and the MS and SAT appropriations.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

SCIENCE, AERONAUTICS AND TECHNOLOGY

For necessary expenses, not otherwise provided for, in the conduct and support of science, aeronautics and technology research and development activities, including research, development, operations, and services; maintenance; construction of facilities including repair, rehabilitation, and modification of real and personal property, and acquisition or condemnation of real property, as authorized by law; space flight, spacecraft control and communications activities including operations, production, and services; and purchase, lease, charter, maintenance and operation of mission and administrative aircraft, [$5,690,000,000] *$5,457,400,000*, to remain available until September 30, [1999] 2000. *(Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Acts, 1998.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SCIENCE, AERONAUTICS AND TECHNOLOGY

REIMBURSABLE SUMMARY
(IN MILLIONS OF REAL YEAR DOLLARS)

	BUDGET PLAN		
	FY 1997	FY 1998	FY 1999
SCIENCE, AERONAUTICS AND TECHNOLOGY	**440.4**	**643.0**	**652.6**
SPACE SCIENCE	53.2	87.5	77.2
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	1.1	1.6	1.5
EARTH SCIENCE	290.4	455.5	490.1
AERONAUTICS AND SPACE TRANSPORTATION TECHNOLOGY	87.6	76.2	72.9
MISSION COMMUNICATION SERVICES	8.1	22.1	10.9
ACADEMIC PROGRAMS	--	0..1	--

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1999 ESTIMATES

DISTRIBUTION OF SCIENCE, AERONAUTICS, AND TECHNOLOGY BY INSTALLATION
(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Centrr	Marshall Space Flight Center	Stennis Space Center	Ames Research Center	Dryden Flight Research Center	Langley Research Center	Lewis Research Ceriter	Goddard Space Flight Center	Jet Propulsion Lab	Headquarters
Space Science	1997	1,969,300	8.251	12,605	317.890	0	74.012	0	11,547	113,643	837.534	537.304	50.514
	1998	1,983,800	5,169	25.864	221.920	0	73,440	0	15,224	40,871	880.351	672.715	48.248
	1999	2,058,400	7.889	190,863	123,376	0	83,803	0	10.297	23,471	734,767	757.839	125.995
Life and Microgravity Sciences and Applications	1997	243,700	51,000	6.800	53,800	0	31,200	0	2,000	40.000	25.300	18,000	15,600
	1998	2 14.200	43.700	6,300	54,400	0	24,100	0	400	35,000	13,300	18,500	18.500
	1999	242,000	67.400	3.400	63,300	0	30,200	0	200	32,100	8,000	12.300	25,100
Earth Science	1997	1,361,600	25	4,800	19,537	73.163	22,900	5,707	45,320	35,830	1,024,314	88.410	41,588
	1998	1,367,300	0	3,000	11,300	21.700	11,500	12,800	32,900	1G.200	1,138,200	70.700	43.000
	1999	1,372,000	0	0	7,400	20,000	8,300	15.700	26.200	0	1,179,400	70.000	45,000
Aeronautical Research and Technology	1997	844,200	0	0	6,704	0	192.273	til ,903	324,020	244,000	6.517	1.555	7.228
	1998	907.100	0	0	2.228	0	221,366	82.144	319.835	251.723	4,173	1,436	24,295
	1999	786.000	0	0	2,343	0	219,274	67,511	258,985	226,158	2.567	1,136	8,026
Advanced Space Transportation Technology	1997	336,700	2,827	302	275.279	7.255	10,675	4,952	13,639	5,299	2,466	8,456	5,550
	1998	417,100	12,400	600	328,400	28.800	7,200	3.500	8.400	8,100	0	8,300	11,400
	1999	388,600	7,600	0	312,200	22,400	7,200	8.400	7.800	5,100	0	3,000	14,900
Commercial Technology	1997	158,600	18.818	5.578	33.517	3,912	15,723	3,743	23,204	17.947	28,491	2.284	5,383
	1998	146.700	16.702	6,012	29,760	3,463	15,022	3,317	17,303	16.125	24,977	3,400	10,6 19
	1999	130,400	16,155	5,067	30,921	3,658	12,832	3,312	16,893	14,370	22.527	2.735	1,930
Total Aeronautics & Space Transportation Technology	1997	1,339,500	21,645	5.880	315,500	11,167	218.071	70,598	360,863	267,246	37.474	12.295	18,161
	1998	1,470,900	29.102	6,612	360,388	32.263	243.488	88,961	345.538	275,948	29,150	13,136	46,3 14
	1999	1,305,000	23.755	5.067	345,464	26.058	239,306	79.223	283,678	245,628	25,094	6,871	24.856
Mission Communication Services*	1997	418,600	3.450	0	1,300	0	0	13,800	0	11,101	199,940	186,456	2.553
	1998	395.800	1.000	0	2.100	0	0	14.500	0	10.200	202,600	108,000	2.400
	1999	380,000	4.500	0	300	0	0	13,800	0	10,100	193,800	175.000	4.100
Academic Programs	1997	120.400	6.200	5.200	5.400	3,600	7,600	3.800	4,300	4.800	66,000	3,500	10.000
	1998	120,000	3,900	5.600	8,600	3.900	6.700	3,800	5.500	5,600	62,300	4.500	9,600
	1999	100,000	3,500	5,100	7,700	3.500	5.800	3,400	4.800	3,300	49.500	4.000	0.400
TOTAL SCIENCE, AERONAUTICS AND TECHNOLOGY	1897	5,453,100	90,571	35,285	713.427	87,930	354,383	93.905	424,036	472,620	2,190,562	845,965	144.416
	1998	5,552,000	82.871	47,376	658,708	57,863	359,228	120,061	399,562	383,819	2,325,901	953,551	168,060
	1999	5,457,400	107,044	204,430	547,540	49.558	367.509	112,123	325,175	314,599	2,190,561	1,026,010	234.451

* - Includes an undistributed reduction of $5.0 million (FY 1998)and $21.6 million (FY 1999)to be taken within the fiscal year at the appropriate centers

Space Science

SCIENCE, AERONAUTICS AND TECHNOLOGY

FY 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE

SUMMARY OF RESOURCE REQUIREMENTS

	FY 1997	**FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
* Advanced X-Ray Astrophysics Facility (AXAF).................	184,400	95,800	---	SAT 1-15
* Space Infrared Telescope Facility..................................	--	55,400	111,700	SAT 1-19
* GP-B mission	59,600	57,300	37,600	SAT 1-23
* Cassini	74.600	---	---	SAT 1-26
* Thermosphere, Ionosphere, Mesosphere Energetics And Dynamics (TIMED)...	25,900	52,700	40,800	SAT 1-28
Payload and instrument development	16,900	18,000	29,400	SAT 1-30
* Explorers...	117,500	113,500	114,300	SAT 1-34
* Mars surveyor	90,000	145,200	164,000	SAT 1-46
* Discovery	76,800	76,500	126,500	SAT 1-41
Mission operations and data analysis	596,500	528,500	526,600	SAT 1-66
Supporting research and technology................................	426,600	541,700	604,400	SAT 1-77
Suborbital program ......,..	59,900	83,300	99,600	SAT 1-91
Launch services	240,600	215,900	203,500	SAT 1-96
Total..	1,969,300	1,983,800	2,058,400	

*Total Cost information is provided in the Special Issues section

**The FY 1998 funding column reflects $50 million that has been set aside for potential use of Space Station, depending on future need.

SCIENCE. AERONAUTICS AND TECHNOLOGY

FY 1998 ESTIMATES

BUDGET SUMMARY

Distribution of Program Amount bv Installation	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Johnson Space Center	8.251	5.169	7.889
Kennedy Space Center	12.605	25.864	190.863
Marshall Space Flight Center	317.890	221.920	123.376
Ames Research Center	74.012	73.440	83.903
Langley Research Center	11.547	15.224	10.297
Lewis Research Center	113.643	40.871	23.471
Goddard Space Flight Center	837.534	880.351	734.767
Jet Propulsion Laboratory	537.304	672.715	757.839
Headquarters	56.514	48.246	125.995
Total	1,969,300	1,983,800	2.058. 40Q

OFFICE OF SPACE SCIENCE

PROGRAM GOALS

Humans have a profound and distinguishing imperative to understand our origin, our existence, and our fate. For millennia, we have gazed at the sky, observed the motions of the Sun, Moon, planets, and stars, and wondered about the universe and the way we are connected to it. The Space Science Enterprise serves this human quest for knowledge. As it does so, it seeks to inspire our Nation and the world, to open young minds to broader perspectives on the future, and to bring home to every person on earth the experience of exploring space.

The mission of the Space Science Enterprise is to solve mysteries of the universe, explore the solar system, discover planets around other stars, search for life beyond earth; from origins to destiny, chart the evolution of the universe and understand its galaxies, stars, planets, and life.

In pursuing this mission, we develop, use, and transfer innovative space technologies that provide scientific and other returns to all of NASA's Enterprises, as well as globally competitive economic returns to the Nation. We also use our knowledge and discoveries to enhance science, mathematics, and technology education and the scientific and technological literacy of all Americans.

In accomplishing its mission, the Space Science Enterprise addresses most directly the following NASA fundamental questions:

> How did the universe, galaxies, stars, and planets form and evolve? How can our exploration of the universe and our solar system revolutionize our understanding of physics, chemistry, and biology?
>
> Does life in any form, however simple or complex, carbon-based or other, exist elsewhere than on planet earth? Are there earth-like planets beyond our solar system?

The four long-term goals of the Space Science Enterprise are:

> Establish a virtual presence throughout the solar system, and probe deeper into the mysteries of the universe and life on earth and beyond—a goal focused on the fundamental science we will pursue;
>
> Pursue space science programs that enable, and are enabled by, future human exploration beyond low-earth orbit—a goal exploiting the synergy with the human exploration of space;

Develop and utilize revolutionary technologies for missions impossible in prior decades—a goal recognizing the enabling character of technology; and

Contribute measurably to achieving the science, mathematics, and technology education goals of our nation, and share widely the excitement and inspiration of our missions and discoveries—a goal reflecting our commitment to education and public outreach.

$50 million in the FY 1998 budget has been reserved for the potential use of Space Station, depending on the outcome of future appropriation action. All Space Science program commitments, products, and scheduled events can be met even after the $50 million appropriations transfer to Human Space Flight.

STRATEGY FOR ACHIEVING GOALS

Science

The Space Science Enterprise pursues the study of origins, as well as studies of the evolution and destiny of the cosmos, by establishing a continuum of exploration and science. It creates a virtual presence in the solar system, exploring new territories and investigating the solar system in all its complexity. It simultaneously probes the universe to the beginning of time, looking ever deeper with increasingly capable telescopes, scanning the entire electromagnetic spectrum from gamma rays to radio wavelengths. It also sends probes into interstellar space, beginning a virtual presence even beyond the solar system.

The strategy of the Enterprise is to conduct world-class research, to maximize the scientific yield from our current missions, and to develop and deploy new missions within the "faster, better, cheaper" framework of a revolutionized NASA.

Fulfilling one major commitment of previous strategic planning, the Enterprise will complete the deployment of the four "Great Observatories" with the launch of the Advanced X-ray Astrophysics Facility (AXAF) in 1998 and the Space Infrared Telescope Facility (SIRTF) in 2001. Complementing the discoveries of the Hubble Space Telescope and the Compton Gamma Ray Observatory launched earlier in this decade, AXAF and SIRTF are certain to add to this bounty and help unravel the mysteries of the universe.

With the July 4, 1997, landing of the Mars Pathfinder, a mission of the Discovery series of spacecraft, the Enterprise visibly demonstrated that such "faster, better, cheaper" programs can yield exciting and inspiring achievements as well as a wealth of knowledge. Through programs such as Discovery and Explorer, the Enterprise will continue to accept prudent risk, shorten development time, explore new conceptual approaches, streamline management, and make other changes to enhance efficiency and effectiveness.

A key aspect of our strategic planning is to ensure the Enterprise acquires the advice of the external science community, and in particular the National Academy of Sciences. In addition, there is extensive collaboration with this community, international partners, and other federal agencies, such as the National Science Foundation, Department of Defense, and Department of Energy, in the conduct of our missions and research.

As a visible link to future human exploration beyond earth orbit, Space Science Enterprise robotic missions help develop the scientific knowledge such ventures will need. At the same time, the Enterprise will benefit from the opportunities human exploration will offer to conduct scientific research that may stretch beyond the capabilities of robotic systems.

To achieve its long-term goal in science, the Enterprise will develop and bring to flight readiness revolutionary technologies in advanced miniaturization, intelligent systems, autonomous operations, and simulation-based design. We will bring the same spirit of innovation and change that embodies our flight programs to our agency-wide responsibility to maintain a vigorous core program of cross-cutting technology development, especially in long-term, high-risk, high-payoff areas.

Education and public outreach

Our education and public outreach goals and objectives involve establishing new directions for the Space Science Enterprise. The traditional role of the Enterprise in supporting graduate and postgraduate professional education—a central element of meeting our responsibility to help create the scientific workforce of the future—is being expanded to include a special emphasis on pre-college education and on increasing the public's knowledge, understanding, and appreciation of science and technology.

Our strategy for realizing our education and public outreach goals begins with incorporating education and public outreach as an integral component of all of our activities—flight missions and research programs. It focuses on identifying and meeting the needs of educators and on emphasizing the unique contributions the Space Science Enterprise can make to education and to enhancing the public understanding of science and technology. It is directed towards optimizing the use of limited resources: encouraging a wide variety of education and outreach activities: channeling individual efforts towards high-leverage opportunities: developing high-quality education and outreach activities and materials having local, state, regional, and national impact: and ensuring that the results of our education programs are catalogued, evaluated, archived and widely disseminated. It supports NASA's overall education program and is aligned with NASA's efforts to ensure that participation in NASA missions and research programs is as broad as possible. It is centered on brokering and facilitating the formation of partnerships between space scientists and a wide range of individuals and institutions across the country engaged in education and in communicating science and technology to the public. It makes contributing to education and outreach the collective responsibility of all levels of management in the Space Science Enterprise and all the participants in the Space Science program.

To achieve our education and public outreach goals and objectives, the Space Science Enterprise will adopt the following operating principles. The Space Science Enterprise will:

- Involve scientists in education and outreach in ways that enhance core Space Science research goals

- Make a long-term sustained commitment to integrating education and outreach into Space Science missions and research programs by: 1) providing resources: 2) building education and outreach into all aspects of the Space Science program: and 3) recognizing and rewarding contributions to education and outreach

- Support local, state, and national efforts directed towards systemic reform of science, mathematics, and technology education in close coordination with NASA's Education Division

- Base Space Science-developed educational products and activities on the criteria contained in the national Mathematics, Science, and Technology Education Standards

- Help scientists become involved in education/outreach

- Provide meaningful opportunities for student and teacher participation in Space Science research programs and missions and, in particular, emphasize the development of new opportunities for participation by underserved and underutilized groups

- Enhance the breadth and effectiveness of partnerships among scientists, educators, contractors, and professional organizations as the basis for Space Science education and outreach activities by: 1) focusing on high-leverage opportunities: 2) building on existing programs, institutions, and infrastructure: 3) emphasizing collaborations with planetariums and science museums: 4) coordinating with other ongoing education and outreach efforts inside NASA and within other government agencies: and 5) involving the contractors in the Space Science Enterprise's education/outreach programs

- Make materials widely available and easily accessible, using modem information and communication technologies where appropriate

- Evaluate its education and outreach programs for quality, impact, and effectiveness

The comprehensive approach to education and public outreach developed by the Space Science Enterprise to put these principles into practice is described in more detail in the October 15, 1996 report "Implementing the Office of Space Science Education/Public Outreach Strategy", available in full on the World Wide Web at http://www.hq.nasa.gov/office/oss/pubs.htm

The approach outlined in this report has been explicitly designed to take advantage of, be coupled to, be compatible with, and build upon the very large investments in education being made by school districts, individual states, and other federal agencies— particularly by the National Science Foundation and the Department of Education. By pursuing such a systematic approach, the impact of a modest investment in education and outreach can be enormously amplified, thereby enabling the Space Science Enterprise to make a significant, long-term, and long-lasting contribution to education and the public understanding of science in the United States.

Technology development and transfer

A number of enabling technologies have been identified for the Space Science program, and prioritizing them is one of the most important technology planning tasks. They fall into two general categories. The first is those technologies that provide fundamental capabilities without which certain objectives cannot be met, or that open completely new mission opportunities. The second is those that reduce cost and/or risk to such a degree that they enable missions that would otherwise be economically unrealistic. Both types of developments are essential to the overall goals of the Space Science program. The former category generally represents more mission-specific needs that are tied to detailed measurement objectives, while the latter tends to represent multi-mission applications whose aggregate cost savings effectively enable entire program elements. A well-structured technology investment portfolio must recognize and balance the importance of both categories.

Fundamental enabling capabilities include developments such as high-precision deployable structures that maintain optical paths to within fractions of a wavelength of light. These are required for studying extra-solar planets through optical interferometry, as well as for the next generation of large space telescopes that will see to the edge of the Universe. Highly capable micro-electronics and micro-spacecraft systems, by virtue of their broad applicability and potential for reducing mission costs and development times, enable missions which would otherwise be prohibitively expensive. The importance of these systems and their commercial potential make them one of our most important technology investment areas.

We have identified a number of key capabilities for which we are developing near-term (several years), measurable performance objectives. Achieving these objectives will require significant near-term investment. The objectives will be part of an integrated technology roadmap which will contain milestones against which our progress may be assessed.

To develop these capabilities, the Space Science Enterprise technology program is organized into three elements:

1. A *Core Program* of research supporting mission-specific technologies for Space Science and cross-cutting spacecraft and robotics technologies for multiple NASA Enterprises. The Core Program supports enabling technologies for the next generation of high performance and cost-effective Space Science missions. An aggressive technology development approach is used that allows all major technological hurdles to be cleared prior to a science mission's development phase. Retiring technological risk early in the mission design cycle, while emphasizing innovation to reach previously unattainable goals in mass reduction and performance, are key to the success of many of the missions planned for the next century.

   Cross-Enterprise technology development is generally multi-mission in nature and tends to focus on the earlier stages of the technology life-cycle. Emphasis is on basic research into physical principles, formulation of applications concepts, and component-level performance evaluation. Where appropriate, these developments may extend all the way to subsystem-level development and test for nearer-term missions. These cross-cutting developments are the foundation for most new spacecraft, robotics, and information technologies eventually flown on NASA missions.

2. Several ***Focused* Program** are dedicated to specific high-priority technology areas. These can encompass developments from basic research all the way to infusion into science missions. They are driven by the needs of Space Science, but other Enterprises are likely to benefit from them. Focused programs includes the mission studies which effectively form the front end of the overall technology development program. Scientists work collaboratively with technologists and mission designers to develop the most effective alignment of technology development programs with future missions. This collaboration enables intelligent technology investment decisions by fully exploring the design and cost trade space. These studies will utilize new techniques for integrated design and rapid prototyping to ensure that realistic and implementable decisions are reached.

   There are presently four Focused Programs:

   Advanced Deep Space System Development. This program will develop, integrate, and test revolutionary technologies for solar system exploration. Emphasis will be on micro-avionics, autonomy, computing technologies, and advanced power systems. Along with other technologies, these will be integrated as advanced engineering-model flight systems to form the basis for the new generation of survivable, highly capable micro-spacecraft.

   Astronomical Search for Origins Technology. This program will develop critical technologies for studies of the early Universe and of extra-solar planetary systems. Included are large lightweight deployable structures, precision metrology, optical delay lines, and other technologies for space-based interferometry. Also included are technologies such as inflatable structures and large lightweight optics required by many proposed missions and concepts.

   Structure and Evolution of the Universe Technology. This program will provide the technologies required for missions focused on understanding how the structure of our Universe emerged from the Big Bang, how the Universe is continuing to evolve, and what will be the fate of the Universe. Examples of technology in this area include sensors, detectors, and other instruments, as well as cryocoolers and other instrument support systems.

   Sun-Earth Connections Technology. This program will develop the technologies needed for missions focused on understanding long-term and short-term solar variability, and how solar processes affect the earth. Technologies supported in this area include thermal shielding, integrated fields and particles sensors, and a high-temperature solar array.

3. A ***night*** Validation *Program* called the "New Millennium Program" completes the technology development process by validating technologies in space. New Millennium missions are driven by needs for technology flight validation, but are also designed to return high priority science data within cost and mission constraints. Industry-government partnerships are used to identify technology candidates, complete their development, and select those technologies requiring flight validation. Through this process, high-value technologies are made available for use in the Space Science program without imposing undue cost and risk on individual science missions. The New Millennium Program is funded by both the Space Science Enterprise and the Earth Science Enterprise.

Industry has made and will continue to make significant contributions to the planning, development and implementation of Space Science missions and research programs. Industry has played a critical role in the design, engineering, manufacture, construction, and testing of both large and small space missions; in the design, development, testing, and integration of advanced instruments; and in the development of advanced spacecraft, instrument, mission operations, and information system technologies. Many industry capabilities have been developed for industry's commercial applications with DoD or NASA core technology support. The resulting extensive industrial space infrastructure is available for use by the space science research community. The establishment of partnerships with industry will allow participants in the Space Science Enterprise to better utilize the experience and the capabilities of the industrial sector.

As noted earlier, universities are now partnering with industry to assume full responsibility for the design, development, and operation of entire missions. With the more frequent flight opportunities now being provided through the Explorer and Discovery programs, such partnerships are likely to play an even more important role in the Space Science Enterprise in the future. The reliance on the identification, development and utilization of advanced technology to dramatically lower instrument, spacecraft, and mission operations costs requires strong partnerships between industry and the Space Science Enterprise. Strong partnerships are also important for facilitating the transfer of NASA-developed technology to industry and, in *so* doing, realizing the commercial potential of these technologies and contributing to the long-term capability and competitiveness of American industry.

MEASURES OF PERFORMANCE

The Office of Space Science (OSS) has been working with the Office of Management and Budget, the NASA Advisory Committee, and NASA's Office of Policy and Plans to develop metrics in response to the Government Performance and Results Act (GPRA) of 1993. The following metrics will be used to address GPRA.

Fundamental Science

Fundamental Science is the primary objective of the Space Science program, however, it is also among the most difficult of outcomes to measure. OSS has developed two surrogate measures of fundamental scientific performance, each of which are based on assessments that are made independent of NASA. These metrics do not capture all aspects of performance that need to be measured, but they do provide important insight into fundamental scientific performance.

1. "Science News" metric - This metric is based on that journal's annual listing of "most important stories" going back 25 years (1973 - 1997). "Science News" tracks the new discoveries they consider most significant on an annual basis. By tallying the stories based on scientific or technical accomplishments each year, a metric is generated that can be used to compare OSS performance over time as compared to all other "world class" science in fields as diverse as archaeology and biomedicine. By this metric, Space Science discoveries have contributed about 4% of world science return over the past 25-year period.

1997 was another outstanding year, with Space Science accounting for 6.4% of "world-class" science discoveries. This output was led **by** missions in the International Solar-Terrestrial Physics program, particularly SOHO and POLAR, which provided new images and data on solar coronal mass ejections, solved the long-standing mystery of the coronal temperature, and ignited a controversy over the existence of house-sized "snowballs" pelting the earth. Early science returns from Mars Pathfinder and Mars Global

Surveyor accounted for over 1% of discoveries, and HST and Galileo continued to make headlines as well. A number of missions in extended operations (GRO, ROSAT, ASCA, Voyager, and EWE) as well as archival research (COBE, Viking) contributed 1 percent.

2. College Textbook metric - This metric attempts to show how the most significant topics of a single year get incorporated into the overall body of scientific knowledge. Six editions of a popular introductory college astronomy textbook spanning 1979-1995 were analyzed to assess OSS contributions. A new edition was published in 1997, and analysis of the OSS contribution should be completed by late January 1998. Long-term Performance is measured by OSS's capture of "intellectual market share" (i.e. what percentage of the material is based on OSS contributions) as well as by overall growth of knowledge about astronomy.

Textbook material based on Space Science contributions grows steadily, reflecting the cumulative effect of new information which is added to the overall body of scientific knowledge as new discoveries are added.

The textbook grew 33 percent from 1979 to 1996, with the largest contributor being new chapters on Saturn, Uranus and Neptune, resulting from NASA deep space missions to the outer planets.

In 1996, 27 percent of knowledge presented in the textbook was based on OSS contributions, which is double the 13 percent OSS contribution in 1979.

Additional credibility accrues to these two metrics because of the significant correlation between the identification of new discoveries in "Science News" followed by their inclusion into college texts 3-5 years later. An enclosed chart identifies the historical performance of OSS over the past 25 years in accordance with the two metrics just described.

A listing of the "Top Ten" in the Space Science program for 1997 provides another look at performance:

- The spectacular Mars Pathfinder mission captured world-wide public and scientific attention
- The NEAR spacecraft provided stunning images and surprising data from the asteroid Mathilde
- Galileo images of Jupiter's moon Europa suggest the possibility of liquid water beneath its surface
- The Solar and Heliospheric Observatory (SOHO) has multiplied our understanding of the Sun's interior
- SOHO has also recorded many Coronal Mass ejections (CMEs) from the Sun in unprecedented detail
- Hubble Space Telescope was successfully serviced, its new instruments enabling a string of major discoveries
- Hubble found quasars existing in a variety of distant host galaxies
- The Compton Gamma-Ray Observatory saw a fountain of antimatter being emitted from the center of our galaxy
- Studies of the bright comet Hale-Bopp provided numerous surprises
- For the first time, optical counterparts of gamma-ray bursters have been identified

Faster, Better, Cheaper

A major strategic thrust of OSS is to increase overall cost effectiveness of the Space Science Enterprise by providing more frequent access to space for the science community within an increasingly constrained budget environment. Current plans within the Space Science program call for a significant increase in the historical launch rate despite reduced resources. Toward this end, OSS has restructured several missions to reduce cost and schedule requirements. Mission series such as Explorers, Discovery, Mars Surveyor and New Millennium all emphasize the selection of future missions within predetermined cost, schedule and launch services requirements. The success of this new strategy is measured by three important criteria:

1. Development time - Mission development time is a key factor in putting fresh ideas into practice and in the overall cost of a mission, and, therefore, must be reduced from historical levels. OSS plans to reduce development times from an average of more than 9 years for missions launched in 1990-94 to less than four years for missions planned for launch in 2000-04.

   Future Explorers (i.e. MIDEX, UNEX and SMEX) are planned for 2-3-year development times versus 4-5-year development times of previous Delta-class missions.

   Discovery missions are planned for 3-year development schedules (or less)

   Mars Surveyor missions are planned for 3-4-year development schedules

   New Millennium missions are planned for 2-3-year development schedules

2. Development cost - Given the tightly constrained NASA budget plans for the next several years, mission development costs must be reduced, and cost estimate overruns must be eliminated if OSS is to sustain a reasonable launch rate for new missions. Consequently, NASA is now planning the majority of future missions to fit within a predetermined cost "cap" or target.

   Future Explorer missions are targeted at specific costs in FY 1994 dollars, all well below historical cost levels: Medium Explorers (MIDEX) ($70M); Small Explorers (SMEX) ($30-40M); University Explorers (UNEX) ($5M).

   The FUSE mission has been restructured from a $254 million Delta-class mission to a $100 million Med-Lite class mission, while the launch date has been accelerated by approximately two years.

   SIRTF, an FY 1998 new start, has been extensively restructured from its original configuration in order to reduce its development costs by a factor of 4 from the original estimate.

   Discovery missions are constrained to no more than $150 million FY 1992 dollars for development, a fraction of what planetary missions have historically cost. The first four Discovery missions (Mars Pathfinder, NEAR, Lunar Prospector, and Stardust) are actually averaging less than $1 10 million FY 1992 dollars for development.

Mars Surveyor and New Millennium missions, while not strictly capped during the definition phase, are capped at the time of selection for development.

Additional savings are achieved by constraining future mission designs to smaller, less expensive launch vehicles (i.e. Med-Lite, Small-class, Ultra-Lite) as opposed to Delta-class or higher as historically has been the case.

3. Launch rate - The provision of more frequent launch opportunities is essential to foster the next generation of space scientists and engineers, and to provide a more continuous flow of exciting new discoveries.

MIDEX, SMEX and UNEX mission launches are anticipated at the rate of nearly 1 launch per year for each mission class, contingent upon available funding and the specific missions selected. We expect to significantly increase the UNEX launch rate around the beginning of the next decade, assuming availability of low-cost launchers

Discovery and New Millennium missions each support an annual launch rate of 1 launch every 12-18 months

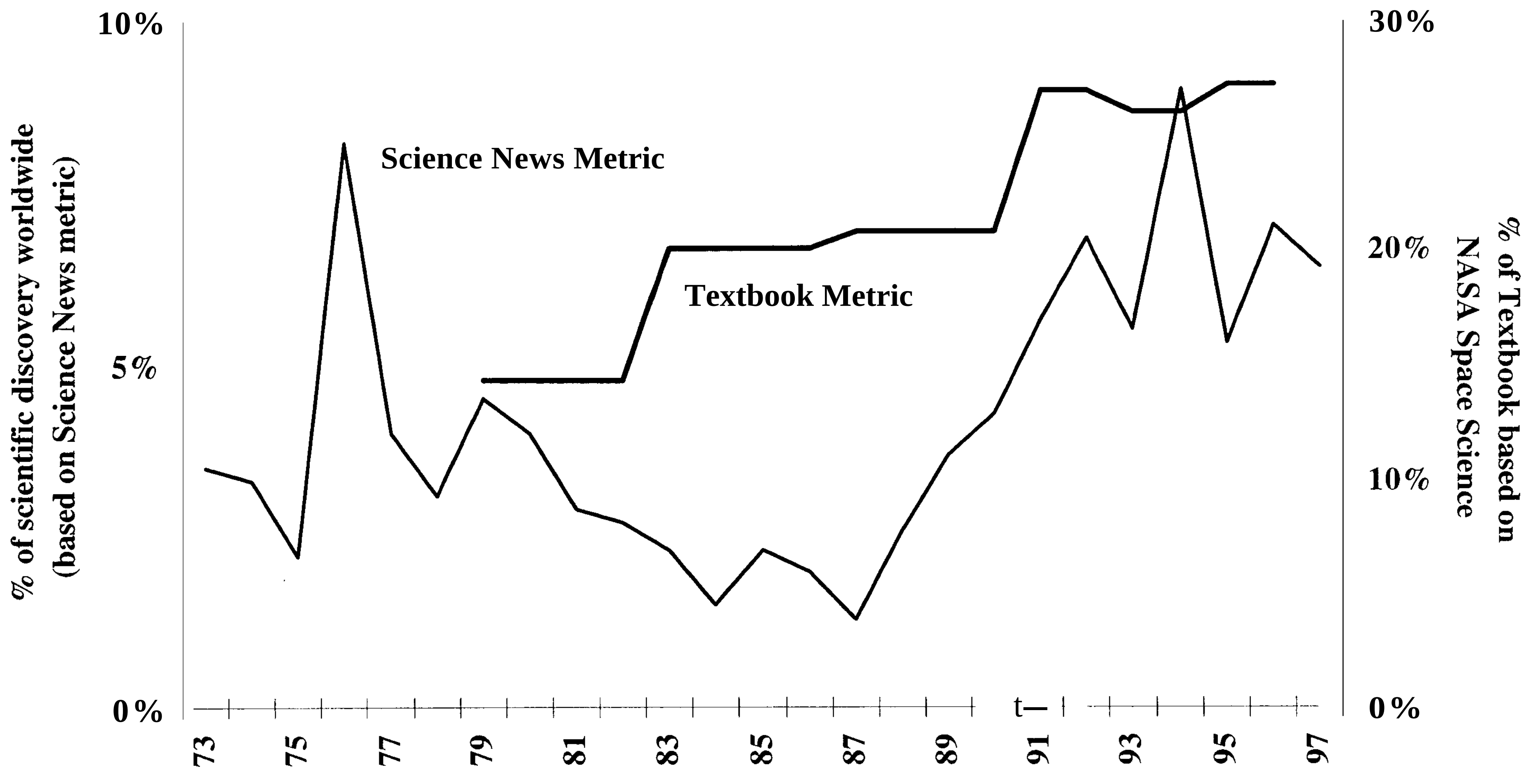
The Mars Surveyor program supports 2 launches at every Mars launch opportunity (i.e. every 26 months)

A graph following this section illustrates the projected trend in declining mission cost and schedule requirements and the accelerated annual launch rate beyond FY 2000.

In addition to reductions in cost and schedule requirements for development and launch of spacecraft, OSS has sought cost effectiveness in mission operations and data analysis (MO&DA). This is the phase where the principal science objectives of every endeavor are accomplished. MO&DA is definitely becoming "better" and "cheaper", as illustrated by the average cost per year of operating missions. In 1992 the Office of Space Science operated 15 missions at an average cost of $22M per year per mission. Our current plans for FY 2003 include operation of **33** missions at an average cost of $5.4M per year per mission, a factor-of-4 improvement. (These figures exclude HST, AXAF, Cassini, and SIRTF, large missions which would skew the data). MO&DA costs have been reduced by using smaller, "smarter" spacecraft and ground systems, accepting more risk in mission operations, reducing funding to scientists after completion of the primary mission phase, and arranging for more international collaborations. A graph following this section illustrates the effects of these changes.

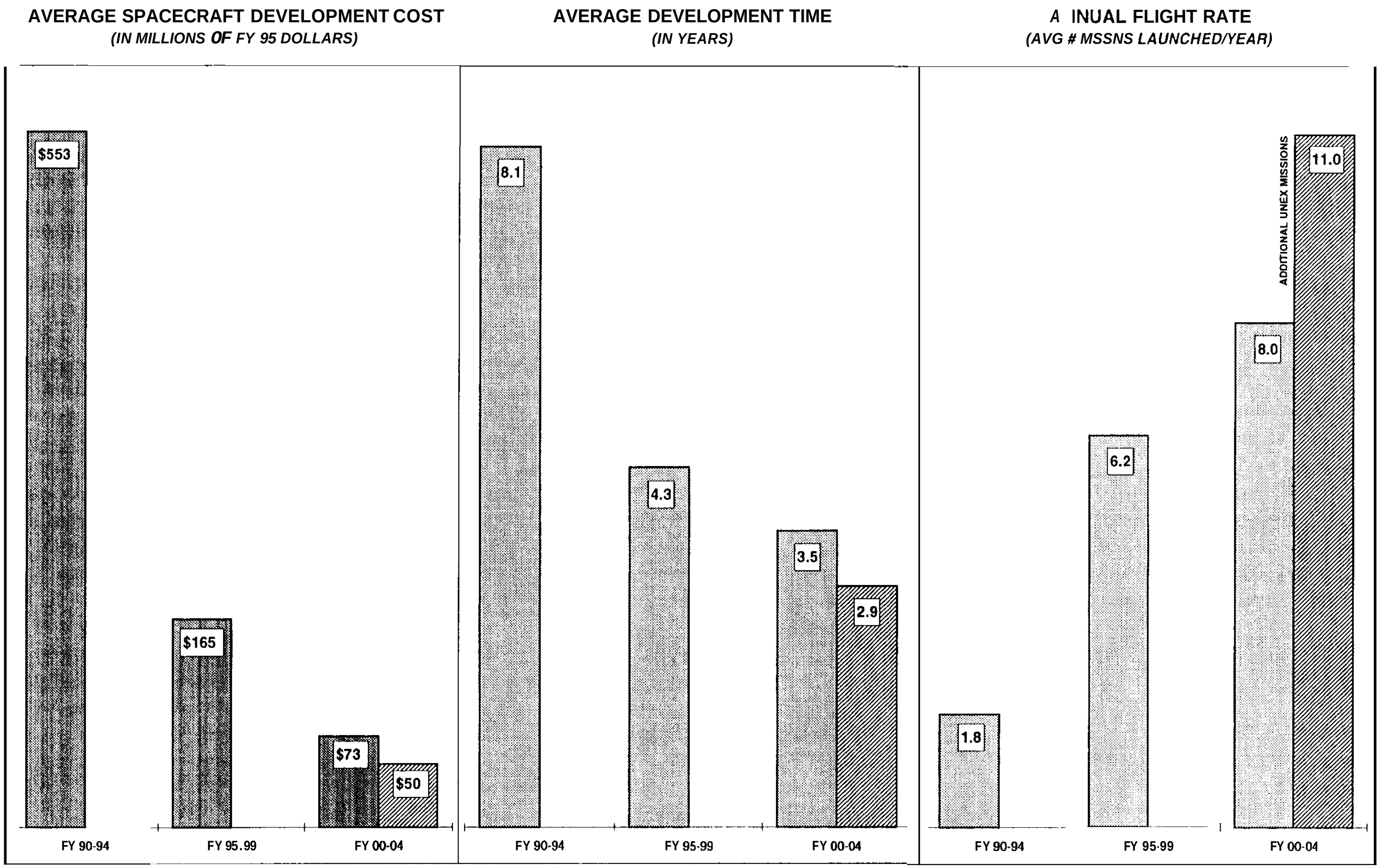
Fundamental Science Metrics

NASA Space Science Contributions Growing!



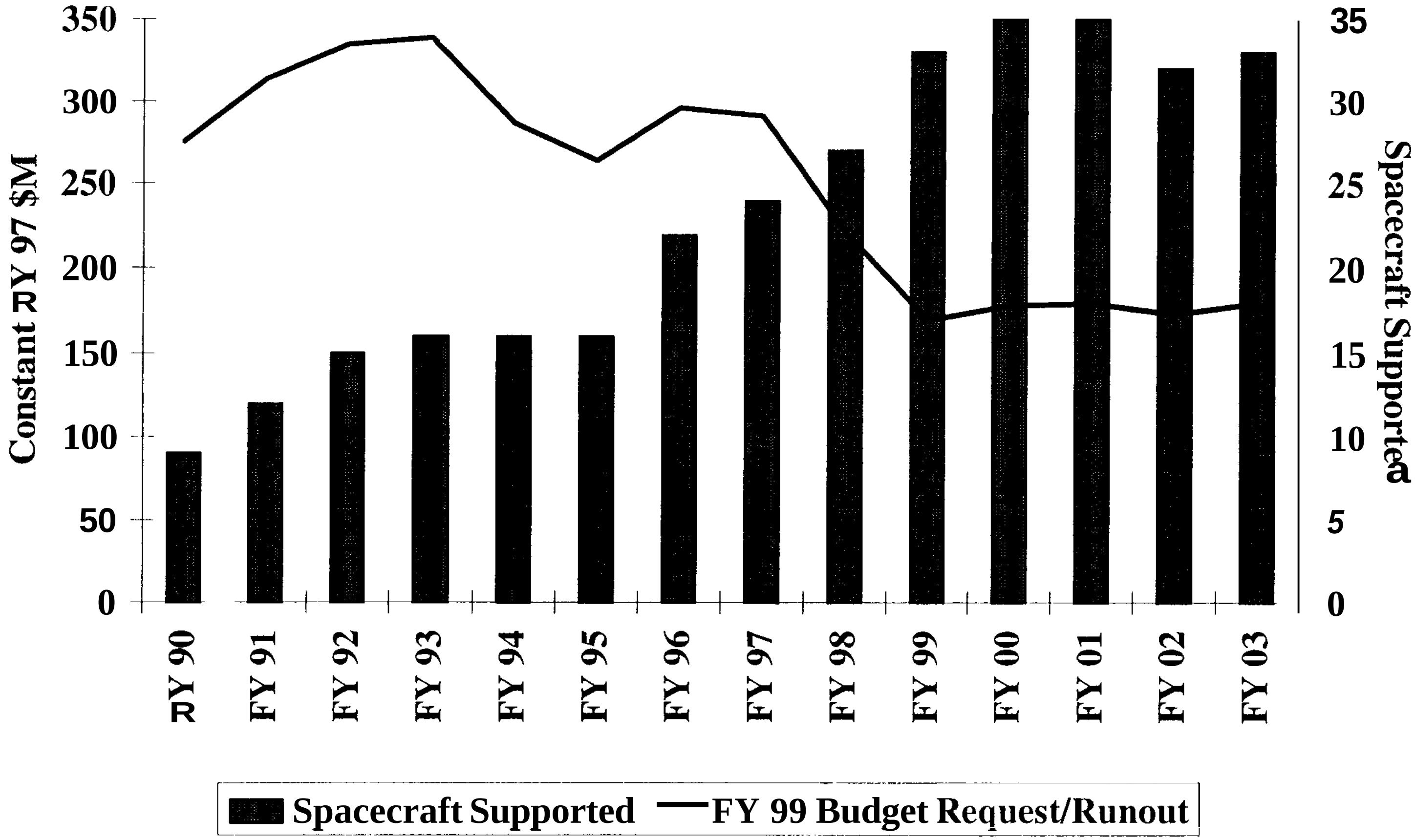
OFFICE OF SPACE SCIENCE

FASTER, BETTER, CHEAPER



Less expensive launches enable additional UNEX flights

OSS Small Mission MO&DA
(excluding HST, AXAF, Cassini, and SIRTF)



BASIS OF FY 1999 FUNDING REQUIREMENT

ADVANCED X-RAY ASTROPHYSICS FACILITY

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Advanced X-Ray Astrophysics Facility development *	184,400	95,800	

* Total cost information is provided in the Special Issues section

PROGRAM GOALS

The Advanced X-ray Astrophysics Facility (AXAF) is the third of NASA's Great Observatories, which include the Hubble Space Telescope and the Compton Gamma Ray Observatory. AXAF will observe matter at the extremes of temperature, density and energy content. Previous X-ray missions, such as the Small Astronomical Satellite-C and the Einstein Observatory have demonstrated that observations in the X-ray band provide a powerful probe into the physical conditions of a wide range of astrophysical systems. With its unprecedented capabilities in energy coverage, spatial resolution, spectral resolution and sensitivity, AXAF will provide unique and crucial information on the nature of objects ranging from nearby stars like our Sun to quasars at the edge of the observable universe. Some of the major scientific questions addressed by *AXAF* include:

What is the age and size of the universe? AXAF will provide an independent measurement at X-ray wavelengths of the Hubble Constant, which determines the answers to these questions. AXAF will be able to resolve and detect individual bright binary sources in galaxies within the Virgo cluster, as well as sources in intermediate galaxies. Thus, the population of bright X-ray sources in hundreds of galaxies can be determined. Since high-energy X-rays are unaffected by obscuring material, the brightness of sources can be accurately measured and the hypothesis that these sources, or a subset of them, are "standard candles" can be accurately tested. If such "standard candles" are found, distances to nearby galaxies can be accurately determined. These distances are a crucial step in the derivation of the Hubble Constant and the potential of these measurements is truly exciting.

What is dark matter? Dark matter accounts for more than 90% of the mass of the universe, but its composition remains a total mystery. The gravitational effects of dark matter have proven its existence, but it has yet to be identified. It may be massive amounts of ordinary matter in the form of small, non-radiating objects yet to be detected, or it may be some exotic new form of matter. AXAF will be able to map the distribution of dark matter in distant clusters of galaxies, contributing to our understanding of this enigma.

What is the X-ray background radiation? Other X-ray missions have seen a faint X-ray background emission covering the entire sky, the nature of which is uncertain. AXAF is expected to detect quasars and active galaxies 100 times fainter than the Einstein Observatory could, and can thus look to significantly greater distances. This is unknown territory, except that the integrated emission from many unresolved faint sources probably contributes most of the X-ray background. Deep *AXAF* observations will come close to imaging this background and will provide a sample of distant objects which record the state of the universe at early times.

STRATEGY FOR ACHIEVING GOALS

The Marshall Space Flight Center (MSFC) was assigned responsibility for managing the AXAF Project in 1978 as a successor to the High Energy Astrophysics Observatory (HEAO) program. The scientific payload was selected through an Announcement of Opportunity (AO) in 1985 and confirmed for flight readiness in 1989. TRW was selected as prime spacecraft contractor for the mission, with major subcontracts to Hughes Danbury (mirror development), Eastman Kodak (High Resolution Mirror Assembly -- HRMA), and Ball Aerospace (Science Instrument Module - SIM). The Smithsonian Astrophysical Observatory (SAO) also has significant involvement throughout the program. AXAF will be launched on the Shuttle with an Inertial Upper Stage (IUS) provided by Boeing. International contributions are being made by the Netherlands (an instrument), Germany (an instrument), Italy (detector test facilities), and the United Kingdom (microchannel plates and science support).

AXAF was given new start approval in FY 1989, with full-scale development contingent upon demonstrating the challenging advances in mirror metrology and polishing technology. The first pair of mirrors was fabricated and tested in a specially designed X-ray Calibration Facility (XRCF) at MSFC in 1991, and the X-ray results validated the metrology and polishing. With the success of this Verification Engineering Test Article (VETA) # 1 demonstration, the program proceeded fully into design and development.

The *AXAF* program was restructured in 1992 in response to decreasing future funding projections for NASA programs. The original baseline was an observatory with six mirror pairs, a 15-year mission in low-earth orbit, and shuttle servicing. The restructuring produced AXAF-I, an observatory with four mirror pairs to be launched into a high earth orbit for a five-year life time, and *AXAF-S*, a smaller observatory flying an X-Ray Spectrometer (XRS). A panel from the National Academy of Sciences (NAS) endorsed the restructured AXAF program. The FY 1994 AXAF budget was reduced by Congress, resulting in termination of the AXAF-S mission. The Committees further directed that residual FY 1994 *AXAF-S* funds be applied towards development of a similar instrument payload on the Japanese Astro-E mission to mitigate the science impact of losing AXAF-S. This activity is underway, and funding for Astro-E activities is requested within the Payload and Instrument Development line.

MEASURES OF PERFORMANCE

Science Instrument Module (SIM) completed Plan: April 1996 Revised: June 1997 Accomplished: May 1997	Fabrication of the Science Instrument Module completed at Ball Aerospace. The SIM will house the two focal plane science instruments on *AXAF*. This milestone was completed in May 1997; a SIM surrogate was delivered to the XRCF in September 1996 to support calibration, with no impact to critical path slack.
Deliver flight instruments	All flight instruments shipped upon completion of their integration and test activities. An ACIS

Plan: August 1996 Revised: January 1997 (I-IRC)& March 1997 (ACIS) Actual: March 1997 (HRC)& April 1997 (ACIS)	surrogate was delivered to the XRCF in September 1996 to support early ACIS/HRMA calibration, with no impact to critical path slack.
X-ray calibration begins at MSFC Plan: January 1997 Actual: January 1997	Tests verified HRMA mirror alignment and compared technical performance of mirrors and science instruments against predicted values.
Complete HRMA/Instrument calibration Plan: April 1997 Actual: May 1997	Verification of end-to-end optical performance.
Begin Observatory assembly and test Plan: October 1997 Actual: October 1997	Initiate integration of completed spacecraft with telescope and instruments at TRW, followed by full-up systems testing (thermal-vacuum, acoustic, etc.).
Deliver Observatory to KSC Plan: June 1998 Revised: TBD	Observatory integration and systems testing completed at TRW. Ship by air to launch site and begin integration with upper stage, final performance testing, and integration in Shuttle. Schedule under review.
Launch Observatory Plan: August 1998 Revised: TBD	Shuttle deployment into low-earth orbit followed by upper stage delivery to highly elliptical operational orbit. Schedule under review.

ACCOMPLISHMENTS AND PLANS

XRCF testing was successfully completed in May 1997. The flight instruments arrived at MSFC in time to be integrated and tested along with the rest of the telescope. Testing demonstrated that the telescope and science instruments are capable of meeting the mission's science objectives by accurately focusing and detecting X-rays.

The HRMA was transported to TRW (west coast) for final integration with the flight SIM and other elements of the telescope assembly. Meanwhile, assembly and test of the spacecraft structure and support systems continued through the end of fiscal 1997. The telescope assembly and the spacecraft were completed in September and October 1997, respectively, leading to the start of Observatory integration and testing in October.

TRW recently notified NASA that it will be unable to deliver AXAF to Kennedy Space Center, FL, on June 1, 1998, because it has experienced delays since October in assembly and testing of the Observatory. The delay is primarily due to TRW's difficulty in configuring and programming its Integrated Spacecraft Automated Test System to test the observatory. No new delivery date has been agreed upon. The agency has directed TRW to develop a plan of action that would show how the contractor can minimize impact to the June 1 delivery. Although a delay in delivery could delay the launch, and could result in additional program costs, the exact impact is not yet known. The delay in delivery of the observatory is unfortunate: however, NASA's first priority is to launch a world-class observatory which has been thoroughly tested and meets all requirements. NASA will work closely with TKW to ensure that happens. Resolution of this issue is expected early in CY 1998; any budget impacts (beyond available program reserves) will be addressed through the Operating Plan process.

BASIS OF FY 1999 FUNDING REQUIREMENT

SPACE INFRARED TELESCOPE FACILITY

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
SIRTF development *	--	55,400	111,700

*Total cost information is provided in the Special Issues section

PROGRAM GOALS

The purpose of the Space Infrared Telescope Facility (SIRTF)mission is to explore the nature of the cosmos through the unique windows available in the infrared portion of the electromagnetic spectrum. These windows allow infrared observations to explore the cold Universe by looking at heat radiation from objects which are too cool to radiate at optical and ultraviolet wavelengths; to explore the hidden Universe by penetrating into dusty regions which are too opaque for exploration in the other spectral bands; and to explore the distant Universe by virtue of the cosmic expansion, which shifts the ultraviolet and visible radiation from distant sources into the infrared spectral region. To exploit these windows requires the full capability of a cryogenically-cooled telescope, limited in sensitivity only by the faint infrared glow of the interplanetary dust. SIRTF is the fourth of NASA's Great Observatories, which include the Hubble Space Telescope, the Compton Gamma Ray Telescope, and the Advanced X-Ray Astrophysics Facility. By completing NASA's family of Great Observatories, an infrared capability will enable the full power of modern instrumentation to be brought to bear, across the entire electromagnetic spectrum, on the central questions of modern astrophysics. Many of these questions can be unraveled only by the full physical picture that this broad spectral coverage uniquely provides.

Rather than simply "descoping" the original Titan-class SIRTF -- the original "Great Observatory" concept -- to fit within a $400 million (FY94) cost ceiling imposed by NASA, scientists and engineers have instead redesigned SIRTF from the bottom-up. The goal was to substantially reduce costs associated with every element of SIRTF -- the telescope, instruments, spacecraft, ground system, mission operations, and project management. With an eye towards cost, and in recognition of the unprecedented sensitivity afforded by the latest arrays, the SIRTF Science Working Group identified a handful of the most compelling problems in modern astrophysics for which SIRTF could make unique and important contributions. These primary science themes, which have received the endorsement of the National Research Council's Committee on Astronomy and Astrophysics, satisfy most of the major scientific themes outlined for the original SIRTF mission in the "Bahcall Report" (whichjudged SIRTF the highest priority major new program for all of U. S. astronomy in the 1990s).

SIRTF is optimized to attack the scientific questions listed below. The first four questions identify the four primary science programs of the SIRTF mission. The fifth question identifies the potential for serendipitous discoveries using SIRTF.

1. How do galaxies form and evolve? SIRTF's deep surveys will determine how the number and properties of galaxies changed during the earliest epochs of the Universe.

2. What engine drives the most luminous objects in the Universe? SIRTF will study the evolution with cosmic time of the ultraluminous galaxies and quasar populations and probe their interior regions to study the character of their energy sources.

3. Is the mass of the Galaxy hidden in sub-stellar objects and giant planets? SIRTF will search for cold objects with mass less than 0.08 that of the sun, not massive enough to ignite nuclear reactions, which may contain a significant fraction of the mass of the Galaxy.

4. Have planetary systems formed around nearby stars? SIRTF will determine the structure and composition of disks of material around nearby stars whose very presence implies that these stars may harbor planetary systems.

5. What lies beyond? SIRTF's greater than 1000-fold gain in astronomical capability beyond that provided by previous infrared facilities gives this mission enormous potential for the discovery of new phenomena.

While these scientific objectives drive the mission design, SIRTF's powerful capabilities have the potential to address a wide range of other astronomical investigations, including studies of the outer solar system, the early stages of star formation, and the origin of chemical elements. Taken together, SIRTF's design capabilities are expected to allow it to achieve many of the initial goals of the Origins program, which are outlined in the Space Science summary section. Moreover, SIRTF's measurements of the density and opaqueness of the dust disks around nearby planets will help set the requirements for future Origins missions designed to directly detect planets.

STRATEGY FOR ACHIEVING GOALS

The Jet Propulsion Laboratory (JPL) was assigned responsibility for managing the SIRTF project. The SIRTF Mission is composed of six major system elements and components as described below. The first three elements (the Science Instruments, Cryo/Telescope Assembly, and Spacecraft Assembly) will be assembled into a single space-based observatory system by means of the fourth element -- System Integration and Test. The fifth element is the launch vehicle, and the sixth is the ground system which will be used to operate the Observatory on the ground prior to launch, and in space to achieve the mission objectives.

Science Instruments will be provided by three Principal Investigators (PIs) selected by NASA in 1984 in response to a NASA Announcement of Opportunity. The three science instruments and their PIs are: the Infrared Array Camera (IRAC), Smithsonian Astrophysical Observatory, Dr. Giovanni Fazio; the Infrared Spectrometer (IRS), Cornel1 University, Dr. James Houck; and the Multiband Imaging Photometer for SIRTF (MIPS), University of Arizona, Dr. George Rieke.

The Cryo/Telescope Assembly (CTA) will be developed by Ball Aerospace and Technologies Corporation, Boulder, CO, as an industrial member of the SIRTF Integrated Project Team. The CTA will consist of all of the elements of SIRTF that will operate in space at reduced or cryogenic temperatures, including the telescope, telescope cover, cryostat, and supporting structures and baffles. The cryostat will contain the cold portions of the PI-provided Science Instruments.

The Spacecraft Assembly will be developed by Lockheed Martin Missiles and Space, Sunnyvale, CA, as an industrial member of the SIRTF Integrated Project Team. The spacecraft assembly will consist of all of the elements of SIRTF that are needed for power, data collection, Observatory control and pointing, and communications. These elements of SIRTF are nominally operated at or near 300 degrees Kelvin, and will also include the warm portions of the PI-provided Science Instruments.

System Integration and Test (SIT) has been identified as a separate system element, and will be provided by Lockheed Martin Missiles and Space, Sunnyvale, CA, as an industrial member of the SIRTF Integrated Project Team. This element will complete the assembly of the Observatory using the science instruments, the CTA, and the Spacecraft Assembly. System level verification and testing, launch preparations and launch of SIRTF will be performed by this element.

Flight and Science and Operations System development will be accomplished in parallel with Observatory development. This will be done to reduce redundant development of ground equipment and software and to assure compatibility between the ground systems and the Observatory after launch. The Flight Operations segment (FOS) will be developed by the mission development team at JPL. The Science Operations Segment (SOS) will be developed by the SIRTF Science Center located at California Institute of Technology's (Cal Tech) Infrared Processing Analysis Center (IPAC).

SIRTF is planned for launch on a Delta 7925-H launch vehicle during FY 2002.

MEASURES OF PERFORMANCE

Non Advocate Review (NAR) Plan: October 1997 Actual: September 1997	The review demonstrated that SIRTF has a plan for design and development that is credible and consistent **with** NASA resources and science community expectations.
Preliminary Design Review Plan: October 1997 Actual: September 1997	Review at the completion of the functional design of SIRTF demonstrated that the project is technically ready to proceed with detail design (Phase C).
Start Phase C/D Plan: April 1998	Approval by NASA to proceed with the design and development of the SIRTF project.
Critical Design Review Plan: October 1998	The review at the completion of the detail design will demonstrate that the SIRTF design is credible within planned resources, and that it satisfies the science community's expectations.
Launch Plan: December 2001	Launch on a Delta launch vehicle to a solar orbit trailing the earth.

ACCOMPLISHMENTS AND PLANS

Please refer to the Supporting Research and Technology section for a discussion of 1997 accomplishments during SIRTF Phase B studies.

SIRTF completed its Preliminary Design Review (PDR) in September 1997, will proceed into detailed design and development phase in 1998. Critical Design Review (CDR is scheduled for October 1998.

SIRTF will complete its spacecraft bus structure by May 1999. Delivery of all of the focal plane arrays will be completed by September 1999. The flight model of the cryostat will be completed by October 1999.

BASIS OF FY 1998 FUNDING REQUIREMENT

RELATIVITY MISSION

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
GP-B Development *...	59,600	*57,300*	*37,600*

*Total cost information is provided in the Special Issues section

PROGRAM GOALS

The purpose of the Relativity Mission (also known as Gravity Probe-B) is to verify Einstein's theory of general relativity. This is the most accepted theory of gravitation and of the large-scale structure of the Universe. General relativity is a cornerstone of our understanding of the physical world, and consequently of our interpretation of observed phenomena. However, it has only been tested through astronomical observation and earth-based experiments. *An* experiment is needed to explore more precisely the predictions of the theory in two areas: (1)a measurement of the "dragging of space" by rotating matter: and (2)a measurement of space-time curvature known as the "geodetic effect". The dragging of space has never been measured, and the geodetic effect needs to be measured more precisely. Whether the experiment confirms or contradicts Einstein's theory, its results will be of the highest scientific importance. The measurements of both the frame dragging and geodetic effects will allow Einstein's Theory to be either rejected or given greater credence. The effect of invalidating Einstein's theory would be profound, and would call for major revisions of our concepts of physics and cosmology.

In addition, the Relativity Mission is contributing to the development of cutting-edge space technologies that are also applicable to future space science missions and transportation systems.

STRATEGY FOR ACHIEVING GOALS

This test of the general theory requires advanced applications in superconductivity, magnetic shielding, precision manufacturing, spacecraft control mechanisms, and cryogenics. The Relativity Mission spacecraft will employ super-precise quartz gyroscopes (small quartz spheres machined to an atomic level of smoothness) coated with a super-thin film of superconducting material (needed to be able to "read-out" changes in the direction of spin of the gyros). The *gyros* will be encased in an ultra-low magnetic-shielded, supercooled environment (requiring complex hardware consisting of lead-shielding, a dewar containing supercooled helium, and a sophisticated interface among the instrument's telescope, the shielded instrument probe, and the dewar). The system will maintain a level of instantaneous pointing accuracy of 20 milliarcseconds (requiring precise star-tracking, a "drag free" spacecraft control system, and micro-precision thrusters). The combination of these technologies will enable the Relativity Mission to measure: (1)the distortion caused by the movement of the earth's gravitational field as the earth rotates west to east; and, (2)the distortion caused by the movement of the Relativity Mission spacecraft through the earth's gravitational field south to north, to a level of precision of 0.2 milliarcsecond per year (the width of a human hair observed from 50 miles).

The expertise to design, build and test the Relativity Mission, as well as the detailed understanding of the requirements for the dewar and spacecraft, resides at Stanford University in Palo Alto, CA. Consequently, MSFC has assigned responsibility for experiment management, design, and hardware performance to Stanford. Science experiment hardware development (probe, gyros, dewar, etc.) and spacecraft development are conducted at Stanford in collaboration with Lockheed Martin Missiles and Space Palo Alto Research Laboratory (LPARL). Spacecraft development and systems integration will be performed by Lockheed Martin Missiles and Space. Launch is scheduled for March 2000 aboard a Delta II launch vehicle.

MEASURES OF PERFORMANCE

Ground Tests-#2 Complete Plan: January 1998 Actual: November 1997	Conduct the third series of performance tests using the flight model dewar and the engineering model probe with a flight-like science instrument assembly.
Flight Probe Delivery Plan: September 1997 Current: February, 1998	The flight probe is the interface between the science instrument and the flight dewar. Flight unit delivery will support payload integration. Delay in schedule.
Flight Probe integrated with Science Instrument Assembly Plan: April 1998 Current: June, 1998	Successful integration of the science instrument (comprised of gyroscopes, telescopes, detection electronics, and gas management) with the probe. Slight delay in schedule.
Flight Telescope Delivery Plan: February 1998	Delivery of the custom, fused-quartz star tracking telescope.
Payload Flight Verification Plan: February 1999	Complete the payload (dewar, science instrument, and probe) testing and verification.
Spacecraft Design, Fab, Assy, and Test Plan: March 1999	Complete the spacecraft design, fabrication, assembly, and test.
Launch Plan: March 2000	Launch aboard a Delta II launch vehicle. Program on schedule to achieve this launch date.

ACCOMPLISHMENTS AND PLANS

The program continues ahead on schedule and is manifested to launch aboard a Delta II in March 2000. (The baseline agreement calls for launch no later than October 2000.) The test series associated with Ground Test Unit #2 (GTU-2) was completed ahead of schedule in November, 1997. GTU-2 demonstrated basic electromagnetic compatibility between the science payload electronics and the highly sensitive detector electronics contained in the heart of the experiment. Successful completion of GTU-2 sets the stage for payload and science instrument integration in the spring and summer of 1998.

The spacecraft development continues ahead of schedule with a "power on" test scheduled for January 1998 with the first flight units. The spacecraft Critical Design Review, originally scheduled for October 1997, was completed two months ahead of schedule in August. Numerous spacecraft components and subsystems will be completed and delivered in late fall 1997 and throughout 1998.

The program was subject to Independent Annual Review and External Independent Readiness Reviews in 1997 and will support like reviews in 1998 and 1999 leading up to final acceptance and launch.

BASIS OF FY 1999 FUNDING REQUIREMENT

CASSINI DEVELOPMENT

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Cassini Development *	74,600	---	---

*Total cost information is provided in the Special Issues section

PROGRAM GOALS

Building on the discoveries made by the Pioneer and Voyager missions, the Cassini program will provide unprecedented information on the origin and evolution of our solar system. It will help tell how the necessary building blocks for the chemical evolution of life are formed elsewhere in the universe. The Cassini mission will conduct a detailed exploration of the Saturnian system including: 1) the study of Saturn's atmosphere, rings and magnetosphere; 2) remote and in-situ study of Saturn's largest moon, Titan; 3) the study of Saturn's other icy moons: and 4) a Jupiter flyby to expand our knowledge of the Jovian System. In conjunction with Galileo's study of the Jovian system, the mission should also provide much insight as to how and why the large, gaseous outer planets have evolved much differently than the inner solar system bodies.

STRATEGY FOR ACHIEVING GOALS

Cassini launched successfully in October 1997 aboard a Titan IV launch vehicle. An extensive cruise period is required to reach Saturn, during which the spacecraft will fly by Venus, Earth, and Jupiter to gain sufficient velocity to reach its destination. Upon arrival in June 2004, the spacecraft will begin four years of study of the Saturnian system that will provide intensive, long-term observations of Saturn's atmosphere, rings, magnetic field, and moons. In conjunction with the observations conducted by the spacecraft, the European Space Agency (ESA) - provided Huygens Probe will be injected into the atmosphere of Saturn's moon Titan. The probe will conduct in-situ physical and chemical analyses of Titan's methane-rich, nitrogen atmosphere, which is a possible model for the pre-biotic stage of the earth's atmosphere. The Cassini spacecraft will also obtain a radar map of most of Titan's surface.

The Jet Propulsion Laboratory (JPL) has been assigned responsibility for managing the Cassini Project and for developing the spacecraft. NASA also has four partners in the Cassini project: the Department of Defense/Air Force provided a Titan IV Centaur launch vehicle; the Department of Energy contributed the Radioisotope Heater Units (RHUs) and Radioisotope Thermoelectric Generators (RTGs); the European Space Agency (ESA) provided the Huygens probe; the Italian Space Agency (ASI) contributed the High Gain/Low Gain Antenna for the spacecraft and elements of the radar mapper.

MEASURES OF PERFORMANCE

Start Spacecraft Environmental Tests Plan: October 1996 Actual: October 1996	Tested entire spacecraft performance in a simulated mission environment to assure proper operation in space.
Ship spacecraft to KSC Plan: April 1997 Actual: April 1997	Completed system-level integration and test activities and integrated the spacecraft onto the Titan IV/Centaur launch vehicle at Kennedy Space Center (KSC).
Spacecraft launch Plan: October 1997 Actual: October 1997	Completed development phase, performed spacecraft checkout and cruise operations, and launched it into orbit.

ACCOMPLISHMENTS AND PLANS

Cassini funding supported completion of the flight-model science instruments, and all remaining integration and test activities prior to shipment of the spacecraft to KSC in April 1997. The Radioisotope Thermal Generators (RTGs) were shipped to KSC by the Department of Energy in April, and were tested with the spacecraft in July. Ground System software development and testing were also completed in July, as was training of the flight operations team. The Launch Readiness Review and the President's launch decision were completed in September 1997.

Cassini launched successfully in October 1997 aboard a Titan IV/Centaur launch vehicle. Cassini is targeted for its first flyby of Venus in April 1998 for a gravitational assist as it begins its seven-year cruise to Saturn.

Please refer to the Mission Operation and Data Analysis (MO&DA) section for a discussion of FY98 - FY99 accomplishments and plans for Cassini.

BASIS OF FY 1999 FUNDING REQUIREMENT

THERMOSPHERE, IONOSPHERE, MESOSPHERE ENERGETICS AND DYNAMICS [TIMED)

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
TIMED Development *	25,900	52,700	40,800

*Total cost information is provided in the Special Issues section

PROGRAM GOALS

The primary objective of the TIMED mission is to investigate the energetics of the Mesosphere and Lower Thermosphere/Ionosphere (MLTI) region of the earth's atmosphere (60- 180 km altitude). The MLTI is a region of transition in which many important processes change dramatically. It is a region where energetic solar radiation is absorbed, energy input from the aurora maximizes, intense electrical currents flow, and atmospheric waves and tides occur; and yet, this region has never been the subject of a comprehensive, long-term, global investigation. TIMED will provide a core subset of measurements defining the basic states (density, pressure, temperature, winds) of the MLTI region and its thermal balance for the first time. These measurements will be important for developing an understanding of the basic processes involved in the energy distribution of this region and the impact of natural and anthropogenic variations. In a society increasingly dependent upon satellite technology and communications, it is vital to understand the atmospheric variabilities *so* that the impact of these changes on tracking, spacecraft lifetimes, degradation of materials, and re-entry of piloted vehicles can be predicted. The mesosphere may also show evidence of anthropogenic effects that could herald global-scale environmental changes. TIMED will characterize this region to establish a baseline for future investigations of global change.

STRATEGY FOR ACHIEVING GOALS

The TIMED mission is the first science mission in a planned program of Solar Terrestrial Probes (STP), as detailed in the Space Science Strategic Plan. TIMED is part of NASA's initiative aimed at providing cost-efficient scientific investigations and more frequent access to space, The TIMED mission is scheduled aggressively, but realistically, for a three year development program, cost-capped at $100 million in FY 1994 dollars. TIMED will be developed for NASA by the Johns Hopkins University Applied Physics Laboratory (APL). The Aerospace Corporation, the University of Michigan, NASA's Langley Research Center with the Utah State University's Space Dynamics Laboratory, and the National Center for Atmospheric Research will provide instruments for the TIMED mission.

TIMED is scheduled for launch in May 2000 aboard a Delta II launch vehicle co-manifested with JASON, an Earth Science mission. TIMED began its 36-month Phase C/D development period in April 1997. TIMED will be a single spacecraft located in a high-inclination, low-earth orbit with instrumentation to remotely sense the mesosphere/lower thermosphere/ionosphere regions of the earth's atmosphere. TIMED will carry four instruments: the Solar Extreme ultraviolet Experiment (SEE), the Sounding of Atmospheric Broadband Emission Radiometry (SABER) infrared sounder, the Global Ultraviolet Imager (GUVI) and the TIMED Doppler Interferometer (TIDI).

MEASURES OF PERFORMANCE

Complete Phase B; start C/D Plan: April 1997 Actual: April 1997	Complete definition study and initiate the 36-month development effort. Accomplished.
Non-Advocate Review Plan: February 1997 Actual: February 1997	Conduct Design Concurrence and Cost Review. Accomplished.
Preliminary Design Review Plan: February 1997 Actual: February 1997	Confirm that the science goals and objectives are achievable within Mission Design. Accomplished
Critical Design Review Plan: December 1997 Actual: December 1997	Confirmation that the design is sufficient to move into full-scale development. Accomplished.
Completion of Instrument Development Plan: December 1998	Complete delivery of all 4 flight instruments to APL. On Schedule.
Begin Spacecraft I&T Plan: January 1999	Spacecraft integration and test in preparation for launch.
Launch Plan: February 2000 Revised: May 2000	Launch aboard a Delta II launch vehicle. Launch date delayed due to co-manifest with Jason.

ACCOMPLISHMENTS AND PLANS

The TIMED mission was initiated in 1994, and completed requirements definition and conceptual design in 1994. Risk reduction efforts were completed in 1995 to ensure that the mission objectives and science goals are achievable within budget. A definition study (Phase B) for the TIMED mission continued throughout FY 1996, and was completed in mid-FY 1997.

A contract for the TIMED development was awarded in the third quarter of FY 1997 to enable full-scale development of the four instruments and the spacecraft. A Preliminary Design Review (PDR) was held in first quarter of 1997, with a Critical Design Review (CDR) in December 1997. Long-lead procurements were initiated in FY 1997 to allow APL to meet its target launch readiness date, May 2000. Instrument and spacecraft subsystem fabrication will take place in FY 1998, and instrument and subsystem integration and test will begin in early FY 1999.

BASIS OF FY 1999 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Astro-E	5,600	7,100	5,200
Rosetta	--	(4,800)	14,800
Cluster-I1	(1,000)	3,300	5,000
Shuttle/international payloads	11,300	7,600	4,400
Total	16,900	18,000	29,400

PROGRAM GOALS

Payload and Instrument Development supports development of hardware to be used on international satellites or on Spacelab missions. International collaborative programs offer opportunities to leverage U. S. investments, obtaining scientific data at a relatively low cost. Spacelab missions utilize the unique capabilities of the Shuttle to perform scientific experiments that do not require the extended operations provided by free-flying spacecraft. The Payload and Instrument Development program supports investigations in Sun-Earth connections, the structure and evolution of the universe, and exploration of the solar system.

STRATEGY FOR ACHIEVING GOALS

In the FY 1994 appropriation, Congress directed **NASA** to pursue flight of a GSFC-developed X-ray spectrometer on the Japanese Astro-E mission. NASA will contribute improved foil mirrors and an X-ray calorimeter derived from the spectrometer previously planned for the canceled AXAF-S mission. This new device will measure the energy of an incoming X-ray photon by precisely measuring the increase in temperature of the detector as the photon is absorbed. It will provide high quantum efficiency over a large instantaneous bandpass, from 0.3 to 10 keV, at an unprecedented spectral resolution of approximately 15 eV over the entire bandpass. The foil mirrors will have a large collecting area, approximately 400 square centimeters at 6 keV, and will provide approximately 2 arc second resolution. These capabilities will permit an unprecedented sensitivity study of a wide range of astrophysical sources, answer many outstanding questions in astrophysics, and likely pose many new ones. Launch is scheduled for February 2000.

The European Space Agency's ROSETTA mission is a cometary mission which will be launched in the year 2003 by an Ariane 5. After a long cruise phase, the satellite will rendezvous with comet Wirtanen and orbit it, while taking scientific measurements. During the cruise phase, the satellite will be given gravity assist maneuvers once by Mars and twice by the Earth. The satellite will also take measurements in fly-bys of two asteroids. U.S involvement in'the Rosetta program includes the development of three remote sensing instruments, as well as support for interdisciplinary scientists and a number of U. S. co-investigators.

The original Cluster mission, part of the International Solar-Terrestrial Physics program, was lost on June 4, 1996 with the explosion of the Ariane-5 rocket. Reflight of the full mission (Cluster-II) has been approved by the European Space Agency and NASA. The four spacecraft will carry out three-dimensional measurements in the earth's magnetosphere, covering both large- and small-scale phenomena in the sunward and tail regions. Launch is scheduled for June 2000 on two Soyuz vehicles.

The Shuttle/International Payloads program supports several other international and U. S. development projects. These include the Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer (ORFEUS) and Interstellar Medium Absorption Profile Spectrograph (IMAPS), to be flown on the German-U. S. Shuttle Pallet Satellite (SPAS); ground-based support for Japan's Very Long Baseline Interferometry Space Observatory Program (VSOP, 1997); portions of two instruments to be flown on Europe's X-ray Mirror Mission (XMM, 1999); and participation in Europe's International Gamma Ray Astrophysics Laboratory (INTEGRAL, 2001).

ORFEUS/IMAPS, which flew aboard the Shuttle in the summer of 1993 and was reflown in November 1996, has explored the character of extreme and far ultraviolet sources, studied the composition and distribution of matter in the neighborhood of the Sun, and performed direct observations of the interstellar medium. FY 1997 was the final year of funding for ORFEUS/IMAPS.

The Japanese VSOP program reached fruition in February 1997 with the launch of the Highly Advanced Laboratory for Communications and Astronomy (HALCA). HALCA allows imaging of astronomical radio sources with significantly improved resolution over ground-only observations. NASA is participating on the science advisory groups and providing ground processing hardware, tracking support, and ground science stations. Starting in FY 98, funding for SVLBI is carried under MO&DA.

The ESA XMM satellite will have highly sensitive instruments providing broad-band study of the X-ray spectrum. This mission will combine telescopes with grazing incidence mirrors and a focal length greater than 7.5 meters with three imaging array instruments and two Reflection Grating Spectrometers (RGS). The U. S. is providing components to the Optical Monitor (OM) and RGS instruments. XMM science will be complementary to the U. S. Advanced X-ray Astrophysics Facility (AXAF). XMM's higher through-put (i.e., higher number of photons collected) will allow somewhat better spectroscopy of faint sources, while AXAF will excel at high resolution imaging. XMM is scheduled for launch in August 1999 on an Ariane V vehicle, and has a lifetime goal of 10 years.

The ESA INTEGRAL mission will perform detailed follow-on spectroscopic and imaging studies of objects initially explored by the Compton Gamma Ray Observatory. Its enhanced spectral resolution and spatial resolution in the nuclear line region will provide a unique channel for the investigation of processes -- nuclear transitions, electron/positron annihilation, and cyclotron emission/absorption -- taking place under extreme conditions of density, temperature, and magnetic field. U. S. participation consists of co-investigators providing hardware and software components to the spectrometer and imager instruments; a co-investigator for the data center; a mission scientist; and a provision for ground tracking and data collection. Launch is expected in March 2001; INTEGRAL has a design life of two years.

MEASURES OF PERFORMANCE

Astro-E:

Flight model spectrometer delivery to Japan Plan: July 1997 Revised: December 1997-May 1998	This task concludes the XRS instrument construction phase and begins a period of validation, testing and calibration. Expected to be completed late, with subcomponents delivered to Japan as completed, but still supports the Japanese schedule.
Final mirror quadrant delivery Plan: December 1998	Satisfies NASA's commitment to provide the X-ray mirrors for the mission to Japan.
Launch Plan: February 2000	Launch on Japanese ELV.

Rosetta:

Start Phase C/D Plan: January 1999	Start of detailed design and fabrication.
Launch Plan: January 2003	Launch on foreign ELV.

Cluster-II:

First flight model instrument set delivered Plan: September 1998	The U.S will provide an identical set of instrument hardware for each of the four Cluster-II spacecraft: the first set is on schedule for delivery in September 1998.
4th/final flight model instrument set delivered Plan: August 1999	On schedule.
Launch Plan: June 2000	Launch on Ariane-5 ELV.

Other Shuttle/International:

VSOP launch Plan: September 1996 Actual: February 1997	Instrument/spacecraft integration and test completed on time: launch delayed by Japanese due to launch vehicle concerns.
XMM: deliver RGS FM-2 components Plan: May 1998	Delivery of U. S. Reflection Grating Spectrometer Flight Model-2 components to Germany for calibration testing with the X-ray telescope. On schedule.
XMM Launch Plan: August 1999	Launch on foreign ELV.
INTEGRAL: Critical Design Review Plan: June 1999	This ESTEC/ESA program review will include the U. S.-provided hardware. On schedule.
INTEGRAL Launch Plan: March 2001	Launch on foreign ELV.

ACCOMPLISHMENTS AND PLANS

Delivery of the flight model Astro-E calorimeter components has begun, and will be completed in time to support the Japanese schedule requirements. The first quadrant of flight model mirrors was delivered to Japan in December 1997, and the fifth and final mirror will be delivered by December 1998. The project is on schedule for a February 2000 launch.

Selection of the Rosetta orbiter instruments, including the U. S. contribution, was completed in mid-FY 1996. Phase B studies began mid-FY 1997. Phase C/D development of the instruments will begin in January 1999.

Deliveries of the 2nd, 3rd, and 4th Cluster-II flight model sets will occur throughout FY 1999, supporting ESA's June 2000 launch date.

VSOP was successfully launched by the Japanese in February 1997.

XMM Flight Model-1 RGS components were shipped on schedule in June 1997; FM-2 delivery is scheduled for May 1998. The U. S. will support integration of instruments onto the spacecraft, and spacecraft integration with the launch vehicle, up through planned launch in December 1999.

INTEGRAL engineering model instrument delivery to ESTEC is scheduled for May 1998. Work on the flight model will continue through FY 99; Flight Model delivery is expected in October 2000.

BASIS OF FY 1999 FUNDING REQUIREMENT

EXPLORER PROGRAM

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
ACE	12,700	---	
FUSE	26,000	22,800	2,600
SWAS, TRACE, WIRE	18,000	17,800	2,300
IMAGE & *MAP*	39,700	46,200	44,700
STEDI (SNOE, TERRIER, CATSAT)	1,800	1,300	400
HETE-II	1,400	3,700	3,300
**Explorer Planning (All Others)	17,900	21.700	61.000
*Total	117.500	113.500	114.300

*Total cost information is provided in the Special Issues section.
**FY98 and FY99 funding for the Explorer Program Technology Initiative has been moved to Supporting Research & Technology.

PROGRAM GOALS

The goal of the Explorer Program is to provide frequent, low-cost access to space for Space Science investigations that can be accommodated with small to mid-sized spacecraft. The program supports investigations in all Space Science disciplines. Investigations selected for Explorer projects are usually of a survey nature, or have specific objectives not requiring the capabilities of a major observatory. The Explorer Program continues to seek reductions in the cost of developing spacecraft, in order to provide more frequent launch opportunities for Space Science missions.

STRATEGY FOR ACHIEVING GOALS

Explorer mission development is managed within an essentially level funding profile. New missions are therefore subject to the availability of sufficient funding in order to stay within the total program budget. Explorer missions are categorized by size, starting with the largest, Delta-class, moving down through the Medium-class (MIDEX), the Small-class (SMEX) and the University-class (UNEX) missions. As part of NASA's efforts to reduce the cost of Explorer missions, no new Delta-class missions are budgeted. Funding for Explorer mission studies is also provided within the Explorer budget.

Delta Class

The Advanced Composition Explorer (ACE) was the last Delta-class mission. ACE was initiated in November 1993, and launched successfully in August 1997. This space physics mission will use nine instruments to study the composition of the solar corona, interplanetary and interstellar media, and galactic matter across a wide range of plasma phenomena. The instruments include six high-resolution spectrometers, designed to have better collecting power than previous systems, to study the mass and charge of plasma phenomena. Three other instruments will provide measures of the lower energy phenomena related to the solar wind. Spacecraft development of ACE was provided by the Johns Hopkins University Applied Physics Laboratory, with project management by GSFC. Foreign participation on ACE includes the University of Bern which provided instrument components, and the Max Planck Institute which provided a flight data system shared by three instruments.

Development of the Far Ultraviolet Spectroscopy Explorer (FUSE) began early in FY 1996. The FUSE mission, previously planned as a Delta-class mission, was restructured in order to reduce costs and accelerate the launch date from CY 2000 to late CY 1998. Although not a MIDEX mission, FUSE can be seen as a transitional step towards the MIDEX program. FUSE will conduct high resolution spectroscopy in the far ultraviolet region. Major participants include the Johns Hopkins University, the University of Colorado, and University of California, Berkeley. Orbital Sciences Corporation was selected by JHU as the spacecraft developer. Canada provides the fine error sensor assembly, and France provides holographic gratings. GSFC provides management oversight of this Principal Investigator-managed mission.

Medium Class

The new Medium-class Explorer (MIDEX) program was initiated to facilitate more frequent flights, and thus more research opportunities, in all OSS themes. Plans call for about one MIDEX mission to be launched per year, with development cost capped at no more than $70 million (FY 1994 dollars) each, excluding the cost of the launch vehicle and mission operations and data analysis. In March 1996 NASA selected the first two science missions for the new MIDEX program, the Microwave Anisotrophy Probe ***(MAP)*** and the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE). The ***MAP*** mission will undertake a detailed investigation of the cosmic microwave background to help understand the large-scale structure of the universe, in which galaxies and clusters of galaxies create enormous walls and voids in the cosmos. GSFC is developing the ***MAP*** instruments in cooperation with Princeton University. The IMAGE mission will use three-dimensional imaging techniques to study the global response of the earth's magnetosphere to variations in the solar wind, the stream of electrified particles flowing out from the Sun. The magnetosphere is the region surrounding the earth controlled by its magnetic field and containing the Van Allen radiation belts and other energetic charged particles. Southwest Research Institute has been selected to develop the IMAGE mission.

Small Class

The Small Explorer (SMEX) program provides frequent flight opportunities for highly focused and relatively inexpensive missions. Each SMEX mission is expected to cost no more than ***$35*** million (in FY 1992 dollars) for design, development and operations through the first 30 days in orbit. Mission definition, development, and launch of these SMEX missions are managed by the Explorer Project Office at the Goddard Space Flight Center (GSFC).

The Submillimeter Wave Astronomy Satellite (SWAS) mission initiated development in 1991. SWAS will provide discrete spectral data for study of the water, molecular oxygen, neutral carbon, and carbon monoxide in dense interstellar clouds, the presence of which is related to the formation of stars. Major participants include the Smithsonian Astrophysical Observatory, the Millitech Corporation, Ball Aerospace, and the University of Cologne, which provided a spectrometer. Development efforts for the mission are completed, the spacecraft is in storage awaiting launch vehicle availability. The launch of the SWAS mission was delayed from January 1997 to January 1999 due to failures of the Orbital Sciences Corporation (OSC) Pegasus launch vehicle and subsequent Pegasus manifest problems.

The Transition Region and Coronal Explorer (TRACE) mission initiated development in October 1994, and is scheduled for launch in March 1998. TRACE is a solar science mission that will explore the connections between fine-scale magnetic fields and their associated plasma structures. Observations of solar-surface magnetic fields will be combined with observations showing their effects in the photosphere, chromosphere, transition region and corona. Major participants include the Lockheed Palo Alto Research Laboratory and the Harvard-Smithsonian Center for Astrophysics.

The Wide-field Infrared Explorer (WIRE) mission also initiated development in October 1994, and is scheduled for launch in late *CY* 1998. WIRE will detect starburst galaxies, ultraluminous galaxies, and luminous protogalaxies. Major participants in WIRE include Utah State University, Ball Aerospace, Cornel1 University, California Institute of Technology, and the Jet Propulsion Laboratory.

NASA released a SMEX Announcement of Opportunity (AO) in 1997, and selected the High Energy Solar Spectroscopic Imager (HESSI) and Galaxy Evolution Explorer (GALEX) to be the next Small Explorer missions. The Broadband Observatory for Localization of Transients (BOLT) mission was selected for further study. HESSI will observe the Sun to study particle acceleration and energy release in solar flares. GALEX will use an ultraviolet telescope during its two-year mission to explore the origin and evolution of galaxies and the origins of stars and heavy elements to detect millions of galaxies out to a distance of billions of light years. GALEX will also conduct an all-sky ultraviolet survey. The BOLT mission will pinpoint locations of gamma ray bursts, the most energetic objects known in the universe. Bursts emit in a few seconds as much energy as an entire galaxy emits in a year. BOLT will detect the positions of gamma ray bursts and immediately radio this information to telescopes on the ground, enabling visual identification of these quickly-disappearing events.

University Class

University-class Explorer (UNEX) missions are currently planned to help NASA achieve a higher future flight rate. UNEX are very small, low-cost missions managed, designed and developed at universities in cooperation with industry. The program will develop greater technical expertise within the academic community beyond the suborbital class missions currently being flown aboard balloons and sounding rockets, thus creating greater opportunity for students and reducing the required role of NASA in-house expertise. UNEX missions will cost only a few million dollars each for definition, development, and operations. UNEX missions will be similar to the Student Explorer Demonstration Initiative (STEDI) missions (SNOE, TERRIERS, and CATSAT) which are under development. UNEX missions will be capped at $6 million in real year dollars for definition, development, operations, and data analysis.

Missions of Opportunity

The Missions of Opportunity (MOpp) were instituted within the Explorer Program as part of the previously mentioned SMEX AO. MOpp are space science investigations, costing no more than $21 million in FY 1998 dollars, that are flown as part of a non-NASA space mission. MOpp are conducted on a non-exchange-of funds basis with the organization sponsoring the mission. OSS intends to solicit proposals for MOpp with every future Explorer AO. Under the recent SMEX AO, the Two Wide-Angle Neutron-Atom Spectrometers (TWINS) investigation was selected as a MOpp. TWINS will enable three-dimensional global visualization of earth's magnetospheric region, thereby greatly enhancing understanding of the connections between different regions of the magnetosphere and their relation to the solar wind. Instruments for the TWINS mission will be developed by Los Alamos National Laboratory (LANL).

HETE-II

Plans are underway for building HETE-II, an international (France, Italy and Japan) collaboration which is to be launched in October 1999. HETE II will seek to obtain precise positions of gamma-ray bursters and other high-energy transient sources. HETE II is a replacement for HETE-I which was launched 100 miles off the coast of Wallops Island, Virginia, on November 4, 1996, but was lost due to launch vehicle third-stage power failures.

MEASURES OF PERFORMANCE

Advanced Composition Explorer (ACE)

Instrument deliveries complete Plan: December 1996 Actual: October 1996	All instruments ready for physical integration with the spacecraft.
Begin environmental tests Plan: February 1997 Actual: January 1997	Following completion of integration, the spacecraft entered its series of electrical, magnetic, vibration, thermal/vacuum, and balance tests. One month ahead of schedule.
Ship to KSC Plan: July 1997 Actual: June 1997	Spacecraft system level testing successfully completed. Moved to KSC for integration with Delta II launch vehicle. One month ahead of schedule.
Launch Plan: December 1997	Successfully launched earlier than planned.

Actual: August 1997

Far Ultraviolet Spectroscopy Explorer (FUSE)

Integration & Test Plan: April 1998	Assemble and test major spacecraft components. On schedule.
Ship to KSC Plan: September 1998	Complete spacecraft system level testing successfully. Move to KSC for integration with Delta II launch vehicle. On schedule.
Launch Plan: October 1998	On schedule.

Medium-class Explorer Program

<u>IMAGE</u>

PDR Plan: January 1997 Actual: January 1997	Approved for more detailed design analysis, and confirmed that science objectives are achievable.
Spacecraft CDR Plan: August 1997 Actual: August 1997	Confirmed that the mission design is sound, and moved to full-scale development and fabrication.
Complete S/C Environmental Testing Plan: April 1999	Integrate and test major spacecraft subsystems. On schedule.
Ship to WTF Plan: November 1999	Complete development and ship to VAFB in preparation for a launch in January 2000 aboard a Delta-7326 (Med-Lite Class ELV).
Launch Plan: January 2000	Launch aboard a Delta-7326 from WTR. On schedule.

MAP

Mission PDR Plan: January 1997 Actual: January 1997	Approved for more detailed design analysis, and confirmed that science objectives are achievable.
Mission CDR Plan: July 1997 Actual: July 1997	Confirmed that the mission design is sound, and moved to full-scale development and fabrication.
Begin S/C I&T Plan: 3rd Qtr CY 1998	Integrate and test major spacecraft components. On schedule.
Instrument Delivery Plan: 2nd Qtr CY 1999	Complete instrument development and ship for integration with the spacecraft. On schedule.
Launch Plan: January 1997 Actual: January 1997	Launch aboard a Delta-7326 (Med-Lite Class ELV) from the ETR. On schedule.

MIDEX AOs

Release AO Plan: 4th Qtr FY 1998	Release AO to industry. On schedule.
Selection Plan: 4th Qtr FY 1999	Missions selection, and initiate concept studies.

Small-class Explorer Program

SWAS

Launch Plan: TBD/March 1997 Current: January 1999	Delayed due to Pegasus launch vehicle availability

<u>TRACE</u>	
Launch Plan: October 1997 Current: March 1998	Delayed to March 1998 due to Pegasus launch vehicle availability
<u>WIRE</u>	
Start integration and test Plan: October 1997 Actual: October 1997	Assembled major components onto the spacecraft.
Launch Plan: August 1998 Current: March 1999	Delayed due to Pegasus launch vehicle availability.
<u>SMEX AOs</u>	
Release AO to industry Plan: 3rd Qtr FY 1999	Release the final AO to industry. On schedule.
AO Selection Plan: 1st Qtr FY 2000	Missions selection, leading to concept studies.

University-class Explorer Program

<u>AO Activities</u>	
Release of AO Plan: 2nd Qtr FY 1997 Current: January 1998	Release an Announcement of Opportunity (AO) for the first round of UNEX missions. Delayed in getting inputs from industry/potential bidders, and implementing lessons learned from the SMEX and MIDEX AO.
Complete selection Plan: 4th Qtr FY 1997 Current: 4rd Qtr FY 1998	Select the first round of UNEX missions and initiate development activities. Delayed with delayed release of AO.
<u>CATSAT</u>	
Launch Plan: 3rd Qtr FY 1999	Complete development and launch spacecraft into orbit in an Ultra-Lite Class ELV (half Pegasus).

HETE-II

Launch Plan: October 1999	Complete development and launch spacecraft into orbit in an Ultra-Lite Class ELV (half Pegasus). On schedule.

ACCOMPLISHMENTS AND PLANS

ACE launched successfully aboard the Delta-I1 launch vehicle in August 1997. Development of the FUSE, TRACE, and WIRE spacecraft continued throughout FY 1997. The IMAGE and *MAP* missions were confirmed, and proceeded to phase C/D. Spacecraft CDR for the IMAGE mission was held in August 1997. An Announcement of Opportunity (AO) for the next round of Small Explorer (SMEX) missions was released in April, and selections were made in October 1997. HESSI and GALEX were selected for studies, BOLT was selected as an alternate SMEX mission, and TWINS was selected as the Mission of Opportunity. Studies of the High Energy Transient Explorer (HETE)-II mission were also initiated during FY 1997. HETE-II will replace the HETE science data lost due to launch failure in 1997. CATSAT, a STEDI mission, was initiated in early FY 1997 and development efforts for this mission continued throughout the year. CATSAT is baselined for launch in 1999, aboard an Ultra-Lite class ELV. An Announcement of Opportunity (AO) for the UNEX program is targeted for release in December 1997.

Development of the FUSE spacecraft will be completed in 1998. FUSE will be delivered to KSC for final preparations for an October 1998 launch aboard a Med-Lite class ELV. FY 1998 funding will also support final preparations for the TRACE and WIRE launches. TRACE will launch in March 1998 aboard a Pegasus XL launch vehicle, and WIRE will also be launched aboard a Pegasus XL launch vehicle in late CY 1998. SWAS is currently in storage due to Pegasus launch vehicle unavailability. SWAS is currently scheduled for launch in early 1999. Development of the IMAGE and *MAP* missions will continue throughout FY 1998. IMAGE will begin integration and testing of subsystems with the spacecraft structure. IMAGE will launch in January 2000, and *MAP* is scheduled for a November 2000 launch. These two missions will be launched aboard Delta-7326/7426 (Med-Lite class) launch vehicles. Development of the CATSAT mission will continue in preparation for mid-FY 1999 launch on an Ultra-Lite Class ELV. FY 1998 funds are also to be provided for HETE 11 development, with launch of the replacement spacecraft targeted for FY 2000 aboard an Ultra-Lite Class ELV. An Announcement of Opportunity (AO) for the next MIDEX spacecraft (numbers *3* and 4) is scheduled for release in May 1998. Selection for the first round of UNEX missions is expected early in the year, followed by Phase B studies and initial development. TWINS will be undergoing Phase A and B studies during FY 1998, leading to confirmation in December 1998.

Explorers FY 1999 funding will support final preparations for the FUSE launch that is scheduled for October 1998 aboard a Delta-7320, a Med-Lite class ELV. Development of the IMAGE, MAP and HETE-II missions will continue throughout FY 1999. Spacecraft integration and test for the IMAGE mission will continue throughout FY 1999. Spacecraft environmental testing for IMAGE is targeted for completion in April 1999, and shipment to the Western Test Range is expected in November 1999. IMAGE is scheduled for launch in January 2000. *MAP* instruments will be completed and delivered for integration onto the spacecraft in preparation for a November 2000 launch. Selection of the third and fourth MidEX missions is expected in mid FY 1999, followed by eleven-month

Phase B studies. TWINS will enter into Phase C/D in December 1998 and continue throughout FY 1999. **A** mission Preliminary Design Review (PDR) for TWINS is scheduled for March 1999.

BASIS OF FY 1999 FUNDING REQUIREM

DISCOVERY PROGRAM

	FY 1997	FY 1998	FY 1999
		Thousands of (Dollars)	
Lunar Prospector *	19,800	--	--
Stardust *	52,200	42,300	9,800
Genesis *	300	31,400	49,400
Future Missions	4,500	2,800	67,300
Total	76,800	76,500	126,500

*Total cost information is provided in the Special Issues section

PROGRAM GOALS

The Discovery program provides frequent access to space for small planetary missions that will perform high-quality scientific investigations. The program responds to the need for low-cost planetary missions with short development schedules. Emphasis is placed on increased management of the missions by principal investigators. The Discovery program is intended to accomplish its missions while enhancing the U. S. return on its investment and aiding in the national goal to transfer technology to the private sector. It seeks to reduce total mission/life cycle costs and improve performance by using new technology and by controlling design/development and operations costs. A Discovery mission development cost (Phase C/D through launch plus 30 days) must not exceed $150 million (FY 1992 dollars), and the mission must launch within 3 years from start of development. The program also seeks to enhance public awareness of, and appreciation for, space exploration and to provide educational opportunities.

STRATEGY FOR ACHIEVING GOALS

The Lunar Prospector mission was selected as the third Discovery mission in FY 1995 with mission management from the NASA Ames Research Center. The spacecraft was launched successfully on January 6, 1998. Lockheed Martin supplied the launch, spacecraft and instruments, and is providing operations support. Tracking and communications support is supplied by the Deep Space Network. The mission is designed to search for resources on the Moon, with special emphasis on the search for water in the shaded polar regions. In addition, the mission will provide accurate gravity and magnetic models of the Moon, supplement the surface data collected by the Galileo and Clementine missions and provide major additions to our understanding of the origin and evolution of the Earth, Moon, and Planets. The spacecraft carries four scientific instruments. The Gamma Ray Spectrometer (GRS) will provide an elemental analysis of the lunar surface by measuring several key elements; the Neutron Spectrometer (NS) will determine the abundance and distribution of hydrogen in the lunar surface in search of a possible water reservoir; the Alpha Particle Spectrometer *(APS)* will search for gas release events and map their distribution; and the Magnetometer and Electron Reflectometer (MAG/ER) will provide a comprehensive lunar magnetics investigation. In addition, a Doppler gravity experiment (DGE) will be conducted using the spacecraft communications system to provide a map of the lunar gravity field.

The Stardust mission was selected as the fourth Discovery mission in November 1995, with mission management from the Jet Propulsion Laboratory. The mission team has completed the Phase B analysis, and Stardust was approved for implementation in October, 1996. The mission is designed to gather samples of dust from the comet Wild-2 and return the samples to earth for detailed analysis. Stardust will also gather and return samples of interstellar dust that the spacecraft encounters during its trip through the Solar System to fly by the comet. Stardust will use a new material called aerogel to capture the dust samples. In addition to the aerogel collectors, Stardust will carry three additional scientific instruments. An optical camera will return images of the comet; the Cometary and Interstellar Dust Analyzer (CIDA) is provided by Germany to perform basic compositional analysis of the samples while in flight; and a dust flux monitor will be used to sense particle impacts on the spacecraft. Stardust will be launched on the Med-Lite expendable launch vehicle in February 1999 with return of the samples to earth in January 2006.

In October 1997 NASA selected the next two Discovery missions: Genesis and the Comet Nucleus Tour (CONTOUR). The Genesis mission is designed to collect samples of the charged particles in the solar wind and return them to earth laboratories for detailed analysis. It is led by Dr. Donald Burnett from the California Institute of Technology, Pasadena, CA; JPL will provide the payload and project management, while the spacecraft will be provided by Lockheed Martin Astronautics of Denver, CO. Due for launch in January 2001, it will return the samples of isotopes of oxygen, nitrogen, the noble gases, and other elements to an airborne capture in the Utah desert in August 2003. Such data are crucial for improving theories about the origin of the Sun and the planets, which formed from the same primordial dust cloud.

CONTOUR's goals are to dramatically improve our knowledge of key characteristics of comet nuclei and to assess their diversity. The spacecraft will leave earth orbit, but stay relatively near earth while intercepting at least three comets. The targets span the range from a very evolved comet (Encke) to a future "new" comet such as Hale-Bopp. CONTOUR builds on the exploratory results from the Halley flybys, and will extend the applicability of data obtained by NASA's Stardust and ESA's Rosetta to broaden our understanding of comets. The Principal Investigator is J. Veverka of Cornell University; the spacecraft and project management will be provided by the Johns Hopkins University Applied Physics Laboratory of Laurel, MD. Launch is expected in June 2002.

Total Discovery mission development is managed within an approved funding profile. New mission starts are therefore subject to availability of sufficient funding in order to stay within the total program budget. Funding for mission studies is also provided within the Discovery Future Missions budget.

MEASURES OF PERFORMANCE

Lunar Prospector

Launch Plan: October 1997 Revised: September 1997 Actual: January 1998	Development phase complete; start of mission. Rescheduled for September 1997, accelerated one month, to avoid potential launch pad conflicts with Cassini; problems with the new launch vehicle forced delay until January 1998

Stardust

Critical Design Review Plan: June 1997 Actual: June 1997	Confirmed that the project system, subsystem, and component designs are of sufficient detail to allow for orderly hardware and software manufacturing, integration and testing, with acceptable risk. Successful completion freezes the design prior to start of fabrication, integration, and test.
Start Spacecraft Assembly and Test Plan: January 1998	Begin to integrate major components of the spacecraft onto the spacecraft structure. On schedule.
Start environmental tests Plan: June 1998	Begin tests to demonstrate that the assembled spacecraft can withstand the launch and space environments. On schedule.
Launch Plan: February 1999	On schedule.

Genesis

Preliminary Design Review Plan: August 1998	Confirmation that the mission is ready to proceed to Phase C/D. On schedule.
Critical Design Review Plan: May 1999	Confirmation that the mission design is sound. On schedule.
Launch Plan: January 2001	Launch on a Delta ELV

CONTOUR

Phase B Study Start Plan: October 1998	Start of detailed design studies.
Launch Plan: July 2002	Launch on a Delta ELV.

Announcement of Opportunities (AO)

Release Final AO Plan: 3rd Qtr FY 1998	Release an Announcement of Opportunity **(AO)** for the discovery missions. On schedule.
Step 2 Selection Plan: 3rd Qtr FY 1999	Phase 2 selection leading to Phase B studies.

ACCOMPLISHMENTS AND PLANS

The Lunar Prospector integration and test activities were completed in the summer of 1997. Originally scheduled for an October 1997 launch, the schedule was accelerated by one month to avoid conflicts with Cassini. Unfortunately, delays due to the new Lockheed-Martin Athena launch vehicle forced the launch to be rescheduled until January 1998, when the spacecraft was successfully launched.

Assembly and test of Stardust spacecraft components was completed late in calendar year 1997, and integration of components into the spacecraft has begun. Environmental testing will start late in FY 1998, in preparation for launch in February 1999.

In April 1997, five candidate Discovery missions were selected for further study. Following several months of Phase A study and evaluation, the Genesis and CONTOUR missions were selected for development in October 1997. The budget requirements for these missions enabled NASA to begin preparations for another Announcement of Opportunity (AO) almost immediately. A draft AO was released for comment in January 1998, and the final AO will be released in the spring. This should lead to the selection of the next Discovery mission(s) early in FY 1999.

The Genesis mission is off to a fast start, as required to meet its planned launch in January 2001. Phase C/D activities will begin in August 1998, following completion of the Preliminary Design Review. During FY 1999, detailed design activities will continue, leading to the Critical Design Review in May 1999.

The CONTOUR mission will not begin significant activity until the start of Phase B early in FY 1999. The mission plans for twelve months of Phase B studies, followed by the start of Phase C/D development in FY 2000.

BASIS OF FY 1998 FUNDING REQUIREMENT

MARS SURVEYOR PROGRAM

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
98 Orbiter and Lander	86,300	41,100	13,300
01 Orbiter and Lander	----	67,000	100,500
Future Missions	3.700	37,100	50,200
Total	90,000	145,200	164,000

*Total cost information is provided in the Special Issues section

PROGRAM GOALS

Mars has been a primary focus for scientists due to its potential for past biological activity and for comparative studies with Earth. The Mars Surveyor program is a series of small missions designed to resume the detailed exploration of Mars. Missions are planned for launch at every launch opportunity; opportunities occur about every 26 months due to the orbital periods of Earth and Mars. In the near term, missions may either orbit Mars to perform mapping of the planet and its space environment, or actually land on the planet to perform science from the surface. A long-term goal is to perform a sample return mission in 2005, returning Mars rocks for analysis. Earlier missions will facilitate this long-range goal by identifying those areas of Mars which are most likely to contain samples of scientific importance, including (potentially) evidence of past biological activity.

STRATEGY FOR ACHIEVING GOALS

This program began in FY 1994 with the development of the Mars Global Surveyor, an orbiter which will obtain much of the data that would have been obtained from the Mars Observer mission. The orbiter carries a science payload, comprised of 6 of 8 spare Mars Observer instruments, aboard a small, industry-developed spacecraft. MGS was launched in November 1996 aboard a Delta II launch vehicle and placed on a trajectory to Mars. The spacecraft arrived at Mars in September 1997. The spacecraft will use aerobraking to arrive at its final mapping orbit in January, 1999, and mapping operations will begin in March, 1999. This mission is to be succeeded by a series of small orbiters and landers which will make in-situ measurements of the Martian climate and soil composition. Technology developed by the Mars Pathfinder mission will be optimized to reduce lander mission costs and technical risk. An orbiter launch is planned in December 1998, a lander launch in January 1999, two launches in the March/April 2001 opportunity, and launches in the 2003 and 2005 opportunities. The Mars Surveyor program has been augmented in FY 1998 and beyond to permit acceleration of a sample return mission from FY 2007 to FY 2005, while maintaining the ability to develop and launch two spacecraft (an orbiter and a lander) at each opportunity through 2003.

Mars Surveyor mission development is managed within an essentially fixed funding profile. New mission starts are therefore subject to availability of sufficient funding in order to stay within the total program budget. The Office of Space Science has total funding responsibility for the Mars Surveyor program, including the 2001 mission, which is a cooperative mission between OSS, the Office of Space Flight, and the Office of Life and Microgravity Sciences and Applications. Funding the mission studies and the technology activities that support the Mars Surveyor program are highly specific to this mission series: therefore, funding for these items is included in the Mars Surveyor budget.

SURES OF ORMA E

1998 Mars Surveyor Orbiter and Lander

Spacecraft Systems Critical Design Review (CDR) Plan: January 1997 Actual: January 1997	Confirms that spacecraft system, subsystem and component designs are sufficiently mature, compatible with established interfaces (structural, thermal, electrical, etc.), and represent appropriate levels of cost, schedule and technical risk. On schedule.
Start Orbiter Integration and Test Plan: May 1997 Actual: May 1997	Integrate instruments and spacecraft subsystems. Completed on schedule.
Start Lander Integration and Test Plan: July 1997 Actual: July 1997	Integrate instruments and spacecraft subsystems. Completed on schedule.
Start Lander environmental tests Plan: March 1998	Confirm that the spacecraft can tolerate the launch and mission environments that it will face. On schedule.
Start Orbiter environmental tests Plan: January 1998	Confirm that the spacecraft can tolerate the launch and mission environments that it will face. On schedule.
Ship Orbiter spacecraft Plan: August 1998 Current: September 1998	Ship to the launch site.
Ship Lander Spacecraft Plan: October 1998	On schedule.

Launch Orbiter Plan: December 1998	On schedule
Launch Lander Plan: January 1999	On schedule.

2001 Mars Surveyor Orbiter and Lander

Start mission/flight system definition Plan: 3^{rd} Qtr FY 1997 Actual: 1^{st} Qtr FY 1997	Begin definition study for the mission and flight system
Science Instrument selection Plan: 1^{st} Qtr FY 1998 Actual: 1^{st} Qtr FY 1998	Select the Science Instrument(s) to be flown on 2001 Mars Surveyor
Payload Confirmation Review Plan: 3^{rd} Qtr 1998	Confirm that the payload is sufficiently defined to move into full-scale development. On schedule.
Complete Phase B & start C/D Plan: 3^{rd} Qtr FY 1998	Complete definition study and initiate the development effort.
Preliminary Design Review Plan: 3^{rd} Qtr FY 1998	Confirm that the science goals and objectives are achievable within Mission Design.
Critical Design Review Plan: 2^{nd} Qtr FY 1999	confirmation that the design is sufficient to move into full-scale development. On schedule.
Orbiter & Lander ATLO Start Plan: 1^{st} Qtr FY 2000	Begin Assembly, Test and Launch Operations (ATLO)by integrating major components of the spacecraft onto the spacecraft structure.
Ship Orbiter Plan: 1^{st} Qtr FY 2001	Ship to KSC launch site.
Ship Lander Plan: 2^{nd} Qtr FY 2001	Ship to KSC launch site.

Orbiter Launch Plan: 2nd Qtr FY 2001	Launch.
Lander Launch Plan: 3rd Qtr FY 2001	Launch.

ACCOMPLISHMENTS AND PLANS

The Mars Surveyor 98 mission, an orbiter and a lander, will be launched in December 1998 and January 1999, respectively. Lockheed-Martin Aerospace, Denver, was selected through a competitive process as the spacecraft development contractor. The selected payloads for the orbiter include the Pressure Modulator Infrared Radiometer (PMIRR -- a part of the Mars Observer payload) and a Color Imager. A Descent Imager and a comprehensive Volatiles and Climate payload, as well as the New Millennium Microprobe (Deep Space II), have been selected for the lander. The lander will also accommodate a Russian LIDAR atmospheric instrument. The payload confirmation review was conducted in April 1996. Preliminary Design Review was held in March 1996, and the Critical Design Review was held in January 1997. Integration and testing for the orbiter began in May 1997 and for the lander in July 1997. The orbiter payload was delivered for spacecraft integration in October 1997, with the lander payload scheduled for delivery for integration in January 1998. The orbiter and lander are scheduled to launch in December 1998 and January 1999, respectively.

In FY 1997, the Announcement of Opportunity for Mars Surveyor '01 payload was released. In the 1st Qtr. of FY 1998, the instruments were selected, including a Gamma-Ray Spectrometer (GRS – the last remaining Mars Observer instrument) and the Thermal Emission Imaging System (THEMIS), a multispectral imaging spectrometer for the orbiter: and Athena, a name given to an integrated suite of instruments for the rover payload. Preliminary Design Review will be held in June 1998, and the Critical Design Review in March 1999. Assembly and testing for the orbiter will begin in October 1999, and the lander in November 1999. The orbiter and lander are scheduled to launch in March 2001 and April 2001, respectively.

BASIS OF FY 1999 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
HST operations and servicing	213,700	180,400	180,300
HST data analysis...	40,900	39,500	45,600
ISTP mission operations and data analysis	46,200	50,600	---
GRO	10,600	4,000	2,700
AXAF mission operations and data analysis	35,500	41,500	63,300
Galileo mission operations and data analysis	64,400	29,800	16,000
Cassini mission operations and data analysis	15,000	38,100	55,800
Mars Pathfinder mission operations and data analysis.......	9,600	4,400	----
NEAR mission operation and data analysis	3,100	11,000	14,400
Lunar Prospector mission operations and data analysis	800	4,300	2,200
Stardust mission operations and data analysis	---	---	3,500
Mars Surveyor mission operations and data analysis	14,700	19,500	22,500
JPL flight support	42,900	36,600	35,800
Other mission operations and data analysis..	99,100	68,800	84,500
Total..	596,500	528,500	526,600

PROGRAM GOALS

The goal of the Mission Operations and Data Analysis (MO&DA) program is to maximize the scientific return from NASA's investment in spacecraft and other data collection sources. The MO&DA effort is fundamental to achieving the goals of the Office of Space Science program because it funds the operations of the data collecting hardware and the data analysis that produces scientific discoveries. Funding supports satellite operations during the performance of the core missions, extended operations of selected spacecraft, and ongoing analysis of data after the usable life of spacecraft has expired. Funding also supports pre-flight preparations for satellite operations and data analysis activities, and long-term data archiving and data base services. Also supported are preparations for future servicing of the Hubble Space Telescope (HST), including development of advanced science instruments.

The MO&DA program is working to dramatically reduce operations costs while preserving, to the greatest extent possible, science output. To do so, it will accept prudent risk, explore new conceptual approaches, streamline management and make other changes to enhance efficiency and effectiveness.

As of February 1998, 25 operational missions (26 spacecraft) are supported. Astrophysics missions include the Hubble Space Telescope (HST, 1990), the Compton Gamma-Ray Observatory (CGRO, 1991), the Rossi X-ray Timing Explorer (RXTE, 1995), the Extreme Ultraviolet Explorer (EUVE, 1992), U. S. participation in the international Roentgen Satellite (ROSAT, 1990), Japanese Astro-D/ASCA (1993) and HALCA/SVLBI (1997), and the European Infrared Space Observatory (ISO, 1995). Space physics missions include FAST (1996), POLAR (1996), SOHO (1995), WIND (1994), Geotail (1992), SAMPEX (1992), Yohkoh (1991), Ulysses (1990), Voyager 1 and 2 (1977), Interplanetary Monitoring Platform (IMP-8, 1973), and the German Equator-S (1997). Planetary missions include Galileo (1989), the Near Earth Asteroid Rendezvous (NEAR, 1996), Mars Global Surveyor (1996), Cassini (1997). and Lunar Prospector (1998).

STRATEGY FOR ACHIEVING GOALS

Hubble Space Telescope (HST) science operations are carried out through an independent HST Science Institute, which operates under a long-term contract with NASA. Satellite operations, including telemetry, flight operations and initial science data transcription, are performed on-site at Goddard Space Flight Center under separate contract. While NASA retains operational responsibility for the observatory, the Science Institute plans, manages, and schedules the scientific operations. In a single year of operations, the activities of over 500 scientists are supported under the HST program, and over 15,000 observations are recorded. In order to extend its operational life and provide a basis for future enhancements of its scientific capabilities, HST is designed to be serviceable. This requires on-orbit maintenance and replacement of spacecraft subsystems and scientific instruments about every three years. Ongoing modification and upkeep of system ground operations are also performed.

WIND, POLAR, SOHO, and Geotail are the core spacecraft of the International Solar Terrestrial Physics (ISTP)program. WIND measures the energy, mass, and momentum that the solar wind delivers to the earth's magnetosphere. WIND also carries a gamma ray instrument, the first Russian instrument ever to be flown on a U. S. spacecraft. POLAR provides dramatic images of the aurora and complementary measurements to provide a direct measure of the energy and mass deposited from the solar wind into the polar ionosphere and upper atmosphere. SOHO studies the solar interior by measuring the seismic activity on the surface: SOHO also investigates the hot outer atmosphere of the Sun that generates the variable solar wind and UV and X-ray emissions affecting the earth's upper atmosphere, the geospace environment, and the heliosphere. Geotail is a Japan-U. S. spacecraft that explored the deep geomagnetic tail in its first two years of flight and now is exploring the near-tail region on the night side and the magnetopause on the day side of the earth.

The Compton Gamma-Ray Observatory (CGRO)measures gamma-rays, providing unique information on phenomena occurring in quasars, active galaxies, black holes, neutron stars, and supernova, as well as on the nature of the mysterious cosmic gamma-ray bursts.

Pre-launch operations funding for the Advanced X-ray Astrophysics Facility *(AXAF)* program supports the development of a ground control system and a science operations center, and preparation for flight system operation. The AXAF Science Center (ASC) in Boston, developed by the Massachusetts Institute of Technology (MIT), supported X-ray calibration of the flight mirror assembly and instruments using a precursor of the AXAF data system during the pre-launch phase of the program. Post-launch AXAF operations will be conducted from a control center at the ASC.

Galileo is executing a series of close flybys of Jupiter and its moons, studying surface properties, gravity fields, and magnetic fields, and characterizing the magnetospheric environment of Jupiter and the circulation of its Great Red Spot. In December 1997, the program began the Galileo Europa Mission (GEM), a detailed study of Jupiter's ice-covered moon running through 1999.

The Cassini mission will conduct a detailed exploration of the Saturnian system including: 1) the study of Saturn's atmosphere, rings and magnetosphere: 2) remote and in-situ study of Saturn's largest moon, Titan: ***3)*** the study of Saturn's other icy moons: and 4) a Jupiter flyby to expand our knowledge of the Jovian System. Cassini launched successfully on October 15, 1997 aboard a Titan IV/Centaur launch vehicle, and is performing initial activities in support of the seven-year cruise to Saturn. Efforts are underway to ensure proper trajectory through tracking and appropriate targeting maneuvers of the Cassini spacecraft. The health of science instruments will be maintained by periodic checkouts.

Mars Pathfinder operations commenced at launch in December 1996. The spacecraft landed on Mars on July 4, 1997, and science operations continued until communications from the spacecraft ceased in October, well beyond the mission design life.

The Near Earth Asteroid Rendezvous (NEAR) mission flew by earth for its final gravity assist in January 1998, and will arrive at its primary target (the asteroid 433 Eros) in February 1999.

Lunar Prospector operations and data analysis have begun, following launch in January 1998.

Stardust will launch in FY 1999 and will perform activities in support of the five-year cruise to rendezvous with Comet Wild-2.

Mars Surveyor operations commenced with the launch of Mars Global Surveyor in November 1996. The spacecraft reached Mars in September 1997 and has begun the aerobraking maneuvers to achieve its desired mapping orbit.

The Planetary Flight Support (PFS) program provides ground system hardware, software, and mission support for all deep space missions. Planetary flight support activities are associated with the design and development of multi-mission ground operation systems for deep space and high-earth orbiting spacecraft. The program also provides mission control, tracking, telemetry, and command functions for all spacecraft utilizing the Deep Space Network (DSN). At present, PFS supports ongoing mission operations for Voyager, Ulysses, Galileo, Mars Global Surveyor, and Cassini. PFS also supports the development of generic multi-mission ground system upgrades such as the Advanced Multi-mission Operations System (AMMOS). This new capability is designed to significantly improve our ability to monitor spacecraft systems, resulting in reduced workforce levels and increased operations efficiencies for Cassini and future planetary missions. New missions in the Discovery and Mars Surveyor programs will work closely with the Planetary Flight Support Office to design ground systems developed at minimum cost, in reduced time, with greater capabilities, and able to operate at reduced overall mission operations costs. The PFS program also supports the tools, personnel and policy implementation of the Resource Allocation Planning (RAP) team which collates, analyzes and identifies the conflicts associated with Deep Space Network (DSN) tracking requests in order to maximize science and mission return.

The Other MO&DA budget funds a variety of (mostly smaller) missions. RXTE uses three instruments to conduct timing studies of X-ray sources. EUVE is studying the sky at wavelengths once believed to be completely absorbed by the thin gas between the stars. U. S. observers continue to enjoy 50% of the observing time (shared with Germany and the UK) from the highly successful ROSAT X-ray satellite. The Japanese/U. S. Astro-D/ASCA spacecraft is conducting spatially resolved spectroscopic observations of selected cosmic X-ray sources. Japan's Highly Advanced Laboratory for Communications and Astronomy (HALCA) allows imaging of astronomical radio sources with significantly improved resolution over ground-only observations. The JPL VLBI project provides support for the U. S. tracking stations associated with HALCA, coordinates U. S. science efforts together with the National Radio Astronomy Observatory (NRAO), and ensures the delivery of high-quality science data to successful U. S. proposers. The European Space Agency's ISO mission conducts high-sensitivity spectroscopic measurements of infrared astronomy sources, with the participation of a significant number of U. S. scientists. ACE is measuring the composition of the particles streaming from the Sun as well as the high-energy galactic cosmic rays. FAST is a low-altitude polar orbit satellite designed to measure the electric fields and rapid particle accelerations that occur along magnetic field lines above auroras. Extremely high data rates (burst modes) are required to detect the presence and characteristics of the fundamental effects taking place. SAMPEX is measuring the composition of solar energetic particles, anomalous cosmic rays, and galactic cosmic rays. The Yohkoh spacecraft, a cooperative program with the Japanese, is continuing to gather X-ray and spectroscopic data on solar flares and the corona. Ulysses is currently studying the heliospheric environment out to the orbit of Jupiter by measuring the interplanetary medium and solar wind as a function of heliographic latitude. Voyager 1 and 2 are continuing to probe the outer heliosphere and look for the heliospheric boundary with interstellar space as they travel beyond the planets. IMP-8 performs near-continuous studies of the interplanetary environment for orbital periods comparable to several rotations of the active solar regions. Equator-S is a German Space Agency project, with contributions from ESA and NASA, that will provide high-resolution plasma, magnetic, and electric field measurements in several regions not adequately covered by any of the existing ISTP missions.

MEASURES OF PERFORMANCE

Hubble Space Telescope

2nd Servicing Mission Plan: February 1997 Actual: February 1997	Replaced Faint Object Spectrometer (FOS) and Goddard High Resolution Spectrometer (GMRS) with Space Telescope Imaging Spectrograph (STIS); add Near-Infrared Camera and Multi-Object Spectrometer (NICMOS) instrument: replaced other hardware as required.
Advanced Camera System Alignment Completed Plan: September 1997 Actual: September 1997	Completed optical alignment in preparation for final integration and test, prior to shipment to GSFC.

Advanced Camera delivered to GSFC Plan: July 1998	Allows for final testing prior to shipment to the launch site. On schedule.
Launch Readiness Plan: February 1999	Third Servicing Mission payload, including the Advanced Camera for Surveys arid other replacement hardware, ready for Shuttle flight. On schedule.
AXAF	
AXAF Science Center End-to End CDR Plan: January 1997 Actual: February 1997	Validated design maturity in preparation for ASC system development.
Ground systems ready to support Integration and Test Plan: July 1997 Actual: June 1997	Able to proceed with spacecraft integration and test activities.
Ground System Release #4 Plan: December 1997 Actual: January 1998	Full functionality of ground system hardware and software. The completed system will be used by the flight operations team in CY 1998 during training before launch.
Galileo	
Various Encounters Plan: 1997 - 1999	Execute several Europa, Ganymede and Callisto encounters and transmit playback data approximately 2 months after encounter. Proceeding well.
Cassini	
Deep Space Maneuver Plan: March 1998	Burn to target first Venus flyby gravity assist. On schedule.
Venus- 1 Flyby Plan: April 1998	First Venus flyby gravity assist. On schedule.
Deep Space Maneuver-2 Plan: December 1998	Burn to target second Venus flyby gravity assist. On schedule.

Venus-2 Flyby Plan: June 1999	Second Venus flyby gravity assist. On schedule.
Earth Flyby Plan: August 1999	Gravity assist. On schedule.
Mars Pathfinder	
Mars Landing Plan: July 1997 Actual: July 1997	Lander arrived on Martian surface, transmitting engineering and science data back to Earth.
NEAR	
Mathilde Encounter Plan: June 1997 Actual: June 1997	Flew by the asteroid Mathilde, largest asteroid (60 km diameter) observed by spacecraft. Remarkable images and other scientific findings obtained.
EROS arrival Plan: February 1999	Start of primary science mission.
Mars Global Surveyor	
Mars orbit insertion Plan: September 1997 Actual: September 1997	Bum to insert into Mars capture orbit. Completed on schedule.
Initiate Mapping Operations Plan: March 1998 Actual: March 1999	Initiate 2 years of science data acquisition on Mars composition, topography, atmosphere, and magnetic fields. Delayed one year, as the aerobraking schedule was revised due to unanticipated deflections in one of the solar array panels. No loss of science is anticipated.
Planetary Flight Support	
Provide and update tools for the Multi-mission Ground System for all missions Plan: (ongoing)	Ground system and power supply are being continuously updated to make them more robust in avoiding service interruptions as well as more cost-effective.

ACCOMPLISHMENTS AND PLANS

Science results and education

NASA's Space Science spacecraft continue to generate a stream of scientific discoveries. Many of these findings are of broad interest to the general public, as witnessed by widespread media coverage. Recent highlights include results from Mars Pathfinder, Galileo, Hubble Space Telescope, and SOHO, but many other Space Science spacecraft have been "in the news" and extremely scientifically productive as well. NASA is also finding ways to partner with the education community in order to strengthen science, technology, and mathematics education.

The Hubble Space Telescope (HST) is fulfilling its promises, generating an ongoing stream of major scientific discoveries. During five days of spacewalks in February 1997, astronauts flawlessly performed major maintenance and upgrades, replacing older hardware with two new, dramatically improved, scientific instruments: the Near Infrared Camera and Multi-Object Spectrometer (NICMOS) and the Space Telescope Imaging Spectrograph (STIS). These new instruments are helping astronomers probe the universe in greater detail than ever before. In addition, one of the tape recorders was replaced with a state-of-the-art Solid State Recorder (SSR); one of the Fine Guidance Sensors (FGS) was also replaced, along with other electronics. HST is creating great public interest as measured by frequent major news and television reports. Hubble results in the last year include:

- The new Near Infrared Camera/Multi-Object Spectrometer (NICMOS) instrument penetrated the shroud of dust along the back wall of the Orion nebula, located in the "sword" of the constellation Orion. Data revealed what can happen to a stellar neighborhood when massive young stars begin to violently eject material into the surrounding molecular cloud. Although ground- based infrared cameras have previously observed this hidden region known as OMC-1, the Hubble's new instrument provides the most detailed look yet at the heart of this giant molecular cloud. Hubble reveals a surprising array of complex structures, including clumps, bubbles, and knots of material. Most remarkable are "bullets" composed of molecular hydrogen -- the fastest of which travels at more than one million mph (500 km/s). These bullets are colliding with slower-moving material, creating bow shocks, like a speedboat racing across water.

- The new Space Telescope Imaging Spectrograph (STIS) instrument discovered a black hole at least 300 million times the mass of the Sun. The spectrograph made a precise observation along a narrow slit across the center of galaxy M84, located 50 million light-years away. This allowed the instrument to measure the increasing velocity of a disk of gas orbiting the black hole. To scientists, this represents the signature of a black hole, among the most direct evidence obtained to date. In other results, HST data suggests that nearly all galaxies may harbor supermassive black holes which once powered quasars (extremely luminous nuclei of galaxies), but now are quiescent.

- Hubble uncovered over 1,000 bright, young star clusters bursting to life in a brief, intense, brilliant "fireworks show" at the heart of a nearby pair of colliding galaxies. The Hubble image of the galactic collision was printed on the front pages of newspapers around the world as well as on the cover of Newsweek magazine.

- Astronomers have long been mystified by observations of a few hot, bright, apparently young stars residing in well- established neighborhoods where most of their neighbors are much older. HST provided evidence that may help solve the 45-year-old mystery of how these enigmatic stars, called blue stragglers, were formed. For the first time, astronomers have confirmed that a blue straggler in the core of a globular cluster (a very dense community of stars) is a massive, rapidly rotating star that is spinning 75 times faster than the Sun. This finding provides strong evidence that blue stragglers are created by collisions or other close encounters in an overcrowded cluster core.

CGRO results point to the existence of a hot fountain of gas filled with antimatter electrons rising from a region that surrounds the center of the Milky Way galaxy. The nature of the furious activity producing the hot antimatter-filled fountain is unclear, but could be related to massive star formation taking place near the large black hole at the center of the galaxy. Other possibilities include winds from giant stars or black hole antimatter factories.

Among Galileo's most significant discoveries are: Ganymede's magnetic field: volcanic ice flows and melting or "rafting" on Europa's surface that support the premise of liquid oceans (and, potentially, life) underneath: studies of water vapor, lightning and aurora on Jupiter: the discovery of a hydrogen and carbon dioxide atmosphere on Callisto: the presence of metallic cores in Europa, Io and Ganymede and the lack of evidence for such a core in Callisto; and high volcanic activity on Io, with dramatic changes since the Voyagers.

Perhaps the greatest recent accomplishment was the dramatic landing of Mars Pathfinder on July 4, 1997, and the fantastic scientific and educational output of the mission. Returning a plethora of scientific data for three months (well past its design lifetime), the mission also captivated the media and the public. Images were made available almost instantaneously over the World Wide Web, which recorded over 500 million hits from all over the globe by the end of July. The mission has provided evidence that liquid water once existed in large quantities on Mars' surface, and that the planet was more earth-like during its early history than previously believed. Last contact with the spacecraft was made on October 7, 1997. The first scientific papers were published in December: analysis of the data is ongoing.

A 25-minute flyby of the asteroid Mathilde by the Near Earth Asteroid Rendezvous (NEAR) spacecraft on June 27 has resulted in spectacular images of a dark, crater-battered little world assumed to date from the beginning of the solar system. The asteroid's mean diameter was found to be somewhat smaller than researchers originally estimated. A study of the asteroid's albedo (brightness or reflective power) shows that it reflects three percent of the Sun's light, making it twice as dark as a chunk of charcoal. Such a dark surface is believed to consist of carbon-rich material that has not been altered by planet-building processes, which melt and mix up the solar system's original building block materials.

Mars Global Surveyor entered Mars orbit in September 1997. Although achievement of the final mapping orbit has been delayed due to movement of one of the solar panels, the spacecraft has already returned a number of surprising images as well as some unexpected magnetometer data.

The fleet of spacecraft representing the Sun-Earth connection theme have been used, along with numerical/theoretical simulations, to understand the activities and events for the next solar cycle which peaks in 2001. Understanding of the solar cycle is of critical importance to our understanding of "space weather", which is itself crucial to a broad variety of U. S. and global interests, including National Defense, Earth science, Human Space Flight, earth weather prediction, and the operation of satellites in earth orbit. In particular, 1997 saw the start up of the new cycle in the form of major events on January 10-11, April 11, May 12 and November 4-6. These events have been tracked and simulated throughout the entire Sun-Earth system. Some of the events were extremely large X-ray flares (largest since 1989) and coronal mass ejections (CMEs) and others were significant geomagnetic storms, some of which resulted in spacecraft anomalies. The satellite observations plus theories of the highly complex processes involved in the Sun-Earth connection were reported at the 1997 Fall American Geophysical Union meeting (December 8, 1997). Among the highlights:

- SOHO and Yohkoh are the premier satellites for monitoring the build up and eruption of solar events such as CMEs and solar flares. These events can have profound impacts on earth-orbiting satellites, communications and human activities in space. SOHO helioseismology data has led to the first maps of temperatures and densities in the interior of the Sun.

- Radio tracking of CMEs has been triangulated from WIND and Ulysses wave instruments during their interplanetary transit. For example, the January event was first picked up early on the 8th and tracked until arrival at earth on the 10th; backwards extrapolation set the CME initiation date to be early on the 6th, consistent with the SOHO and Yohkoh observations. Imagers and particle spectrometers on POLAR tracked the resulting auroral activity during the subsequent magnetic storms.

- Other results from POLAR include the 'observations' of the previously invisible earth radiation belts by registering energetic neutral atoms (ENAs). The ENAs were created by interactions between the earth's cold exosphere and the hot ion populations. The radiation belt ion source distribution is then deconvolved. These techniques are fundamental to producing the science from future Explorer missions IMAGE and TWINS.

- Geotail investigators have located sources of the elusive neutral-line reconnection regions of the earth's magnetotail. These regions convert magnetic energy of the stressed magnetosphere into particle acceleration. The complex and comprehensive particle distributions measured by the Geotail instruments have been extrapolated backwards to reveal the source regions, indicating the extent of magnetopause out to 10's of earth radii. These source regions are important in understanding the coupling of the solar wind into the magnetosphere.

- SAMPEX and other ISTP electron observations have been correlated to the relative magnetic and physical alignment between Earth and Jupiter. In addition to solar, interplanetary shock and local acceleration mechanisms, relativistic electron populations of the Earth's inner radiation belts are showing contributions to sources at Jupiter.

- The FAST Explorer measurements have revealed very fine particle and field structures in the earth's high-latitude auroral zones. FAST's instruments are directly measuring electric fields parallel to the background magnetic field within these acceleration regions. Small, high-speed solitary structures which are regions of depleted electron charge are observed within upward electron beams that are associated with these parallel acceleration regions.

- Voyagers 1 and 2 continue to explore the outermost regions of the solar system that neither humans nor our machines have ever traversed. Both spacecraft are heading towards the nose of the heliosphere and are the most distant man-made robotics from the earth. Pioneering measurements made by instruments in these regions advance our knowledge of the evolution of solar wind plasma, the interaction of the solar wind with the interstellar medium, the variation of the anomalous cosmic ray signatures, the propagation of shocks, and the nature of the heliospheric radio emission. Two major milestones are expected in the next two decades: the encounter with the termination shock and the crossing of the heliopause and thereafter the first direct measurement of the interstellar medium.

- The Ulysses spacecraft is currently moving southward towards the ecliptic and will reach the aphelion in April 1998 at the distance of 5.4 AU from the Sun. Ulysses will continue moving to the southern part of the heliosphere and will pass over the south pole of the Sun in the September 2000-January 2001 time frame. The primary objective during this phase of the mission will be to characterize the heliosphere as a function of latitude during the period when the solar activity will be at or near maximum. Recent observations showed that variations in the solar wind speed near 5 AU are exceedingly low, indicating that the streamer belt is thin and flat. The evidence also supports a southward displacement of the heliospheric current sheet. Ulysses has discovered significant global differences in the fast and slow solar winds as a function of latitude. The mission investigations also determined that interstellar dust does reach into the inner solar system, and that the velocity and direction of interstellar dust compares well with that of interstellar helium. Another major discovery is that the magnitude of the radial component of the Sun's magnetic field is uniform throughout the polar and the equatorial region, and that the solar wind is expanding from the pole to the equator. Ulysses also unexpectedly found that there was no significant increase in cosmic ray particles in the polar regions, disproving the existence of a "cosmic ray funnel".

A NASA scientist has made the first-ever observation of spinning black holes -- confirming Einstein's theory that black holes spin. The new observations from several orbiting spacecraft (the Compton Gamma Ray Observatory, the Rossi X-Ray Timing Explorer, the Roentgen Satellite, and the Advanced Spacecraft for Cosmology Astrophysics) adds to the growing body of knowledge on how these mysterious objects are formed and behave.

Mission Operations and Future Plans

The Space Science program continues to make progress in lowering MO&DA costs while preserving the science return from operating missions. The program is utilizing the savings, and seeking additional cost reductions, in order to sustain operations of ongoing missions as long as is merited by the science return. The science community both inside and outside of NASA regularly reviews the mission operations program to ensure that only the missions with the highest science return are funded. In addition, we are launching smaller spacecraft, and engaging in more international collaborations. As a result, NASA expects to be able to support an increasing number of operational spacecraft through FY 1999 despite a significantly reduced MO&DA budget. In total, the MO&DA budget will be funding 40 operational Space Science spacecraft at the end of FY 1999, compared to 18 at the beginning of FY 1995. Missions expected to begin operations before the end of FY 1999 include TRACE (3/98), WIRE (9/98), AXAF (early FY 1999), FUSE (10/98), SXG (12/98), Mars '98 Orbiter and Lander (12/98, 1/99), SWAS (1/99) and Stardust (2/99).

Occasionally, Space Science mission operations must be terminated, due to technical reasons and/or declining science output per dollar. The Pioneer mission series was terminated on March 31, 1997 as Pioneer 10 ran out of power. The European Infrared Space Observatory (ISO) is expected to cease operations in early 1998 after it runs out of liquid helium. The Galileo Europa Mission and Lunar Prospector operations will end in FY 1999. Other missions which may terminate operations prior to the end of FY 1999 include ROSAT, EUVE, FAST, and Equator-S.

Planning and hardware development in preparation for the next HST servicing mission in late 1999 continues on schedule. The manifest includes the new Advanced Camera for Surveys (ACS) science instrument, plus other hardware to maintain the health of the spacecraft. Meanwhile, a shuttle mission has been planned to test various electronic components that will be installed during the 1999 mission. This shuttle test flight is currently scheduled for the fall of 1998.

The AXAF ground system is now sufficiently functional to support training of the flight operations team prior to launch. Following launch and insertion into the science orbit, a two-month period of spacecraft checkout is scheduled prior to the initiation of routine science observations.

Galileo completed its primary mission of 2 years duration. Beginning in December 1997, and continuing through 1999, Galileo will execute a detailed study of Jupiter's moon Europa, which may have liquid water oceans. This extended phase, called "Galileo Europa Mission - "GEM" will end with two flybys of the moon Io; data from the first flyby of Io during Jupiter Orbit Insertion were lost due to tape recorder problems. Io is the most volcanically active body in the Solar System.

The Cassini spacecraft launched from Cape Canaveral Air Station on October 15, 1997, and will reach Saturn in July of 2004. The spacecraft instruments and the European Space Agency-provided Huygens Probe have been successfully checked out and the spacecraft has been targeted for its first Venus flyby gravity assist. The Cassini spacecraft will fly by Venus twice (April 1998 and June 1999), Earth once (August 1999), and Jupiter (December 2000) during its seven-year cruise to Saturn. Science instrument operations will commence in June 2002.

In January 1999, NEAR will come within 1000 km of EROS and fire its thrusters several times to orbit the asteroid. For the next year, it will take measurements of EROS at various orbit altitudes. Spacecraft operations will be completed in January 2000.

Lunar Prospector is expected to answer some long-standing questions about the Moon's evolution and potential resources. Researchers hope that the scientific return from the Lunar Prospector mission will make major contributions toward understanding the origin, evolution and current state of not only the Moon itself, but of Earth and the entire Solar System. The most anticipated information will be whether or not Prospector can locate water ice in the deep craters of the Moon's south pole--specifically, by detecting the element hydrogen on the Moon's surface. If water is present in the amounts suggested by the Clementine mission, Prospector should be able to detect it, possibly within a month. Lunar Prospector mission operations are expected to end in FY 1999.

Following Stardust launch in February 1999, spacecraft subsystems will be checked out, and efforts will be underway to ensure proper trajectory through tracking and appropriate targeting maneuvers.

The Mars Global Surveyor (MGS) mission was launched from Cape Canaveral Air Force Station aboard a Delta II 7925 on November 7, 1996. After a 10-month cruise, ending in September 1997, MGS is using a combination of thruster firings and aerobraking for a period of fourteen months to reach a nearly circular mapping orbit. Mapping operations are scheduled to begin in March 1999. MGS will maintain the low circular orbit for two years for the prime mapping portion of the mission. After this period, MGS will raise its orbit to the altitude required for planetary quarantine, and continue operations as a communications relay orbiter for other missions, including the Deep Space II Mars Microprobe.

Ulysses is the first spacecraft to fly out of the ecliptic over the poles of the Sun. It is now approaching the ecliptic again near the orbit of Jupiter. During Ulysses' 1994 and 1995 polar passages, the mission discovered that at high latitudes the solar wind consisted of high speed wind and the galactic cosmic ray flux was more uniform with latitude than was expected. Ulysses will go through the next polar passages during solar maximum, in 2000 and 2001.

BASIS OF FY 1999 FUNDING REQUIREMENT

SUPPORTING RESEARCH AND TECHNOLOGY

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Technologv Program..			
Core Program	187,500	200,800	214,800
Space Science Technology...	55,500	74,500	85,500
Cross-Enterprise Technology......................................	132,000	126,300	129,300
Focused Programs..	26,700	170,700	153,200
Flight Validation (New Millennium Program)...................	45,600	39,700	60,400
Space Science Research and Analvsis..............................	166.800	130,500	176,000
Total..	426.600	541,700	604,400

PROGRAM GOALS

The Space Science Enterprise's Supporting Research and Technology Program is comprised of two major components: the Technology Program and the Space Science Research and Analysis Program. These two elements focus on the activities that occur both before and after flight mission development and operations. The proper levels of investment in technology and research and analysis are essential to obtaining the high-value scientific results that will enable the Space Science Enterprise to fulfill its mission: to solve the mysteries of the universe including its origins and destiny, explore the solar system, discover planets around other stars, and search for life beyond earth. The goals of the Technology Program are to (1) lower mission life-cycle costs: (2) develop innovative technologies; (3) develop and nurture an effective science-technology partnership; (4) stimulate cooperation among industry, academia, and government: and (5)identify and fund the development of important cross-Enterprise technologies. The goals of the Space Science Research and Analysis Program are to (1) enhance the value of current space missions by carrying out supporting ground-based observations and laboratory experiments: (2) conduct the basic research necessary to understand observed phenomena, and develop theories to explain observed phenomena and predict new ones; and, (3) continue the analysis and evaluation of data from laboratories, airborne observatories, balloons, rocket experiments and spacecraft data archives. In addition to supporting basic and experimental astrophysics, space physics, and solar system exploration research for future flight missions, the program also develops and promotes scientific and technological expertise in the U. S. scientific community.

STRATEGY FOR ACHIEVING GOALS

The Space Science Enterprise's Technology Program consists of three major elements: core program, focused programs, and flight validation. These elements are designed to develop technologies from the conceptual stage to the point where they are ready to be incorporated in the full-scale development of science mission spacecraft.

Core Programs are comprised of two major components: Space Science Technology and Cross-Enterprise Technology.

Space Science Technology supports the development of enabling technologies for the next generation of high-performance Space Science missions. *An* aggressive technology development approach is used that allows all major technological hurdles to be cleared prior to a science mission's development phase. Retiring technological risk early in the mission design cycle, while emphasizing innovation to reach previously unattainable goals in mass reduction and performance, are key to the success of many of the missions planned for the next century. The Space Science Technology program includes Explorer Program Technology, Advanced Radioisotope Power System *(ARPS)*, Center for Integrated Space Microsystems (CISM), Information Systems, High Performance Computing and Communications (HPCC), science instrument development, and other OSS core technology. These elements are described below:

- Explorer Program Technology develops leading-edge technologies to enable partnerships in relatively small technology projects with industry, academia, NASA Field Centers, and other government agencies. These technologies must show application across multiple systems or missions, with an emphasis on meeting Explorer Program technology needs for improved spacecraft and instrument systems, and must also lead to lower mission costs.

- ARPS provides for the development of technologies in support of an advanced power system for the next generation of solar system exploration vehicles. This activity is performed jointly with the Department of Energy.

- The CISM effort is intended to "leap-frog" currently planned technology developments to fulfill the long-term vision of "spacecraft on a chip," in which all electronic, power control, computational, and communications functions can be accomplished on small integrated chips.

- Information Systems provides multidisciplinary science support in the areas of data management and archiving, networking, scientific computing, visualization, and applied information systems research and technology.

- The NASA HPCC Program will accelerate the development, application, and transfer of high-performance computing technologies to meet the science and engineering needs of the U. S. science community and the U. S. aeronautics community. Within this program the Space Science Enterprise funds the Remote Exploration and Experimentation (REE) component, which will develop low-power, fault-tolerant, high-performance, scaleable computing technology for a new generation of microspacecraft.

- Science instrument development funds initial technology work on new types of detectors and other scientific instruments. Many of these new instrument concepts are tested and flown aboard sounding rockets or balloons, and may later be adapted for flight aboard future free-flying spacecraft.

- Other Space Science Core Technology provides funding to those technologies that are applicable to multiple focused programs (described below). Technologies eventually move from this category into a focused program if they are determined to be feasible and applicable to specific Space Science needs.

The Cross-Enterprise Technology program [previously called Advanced Space Technology) supports the cross-cutting technology requirements for NASA Space Enterprises. The technologies are generally multi-mission in nature and this work tends to focus on the earlier stages of the technology life-cycle. Emphasis is on basic research into physical principles, formulation of applications concepts, and component-level performance evaluation. Where appropriate, these developments may extend all the way to subsystem-level development and test for nearer-term missions. The technologies developed under the Cross-Enterprise program form the foundation for most new spacecraft, robotics, and information technologies eventually flown on NASA missions. The Cross-Enterprise Technology program includes spacecraft systems technology, instrument/sensing technology, autonomy and operations, telerobotics, and communications. These elements are described below:

- Spacecraft systems technology funds developments in power and propulsion, materials and structures, electronics and avionics, and systems analysis. This program places special emphasis on integrated design techniques and fabrication methods to produce modular spacecraft incorporating micro-systems and micro-instruments. *Also* included is the electrical, electronic, and electro-mechanical (EEE)parts program, moved from the Office of Safety and Mission Assurance to the Office of Space Science, beginning in FY 1999. EEE parts provides for the qualification of advanced electrical, electronic, and electro-mechanical parts and packaging technologies. The development and use of parts selection databases is also included in this area.

- Instrument/sensing technology is focused on reducing the size and complexity of science payloads in order to reduce the cost of future missions. This program will also stress the development of instruments with new scientific capabilities, such as detectors and measurement systems to allow scientific measurements in new regions of the electromagnetic spectrum.

- Autonomy and operations technology will examine the use of new approaches to reduce the life-cycle cost of science missions. This program will emphasize on-board autonomy as well as highly intelligent ground systems to allow hands-off spacecraft operations and automated science data analysis and archiving.

- The telerobotics program will enable lower cost planetary rovers with greater capability. (The Mars Pathfinder mission has already demonstrated the first-ever telerobotically operated rover on another planet). Telerobotics technology will also be pursued to reduce the cost of on-orbit activities such as the assembly and servicing of science satellites, as well as to allow the automated tending of science payloads.

- Communications technology funds the development of advanced spacecraft-based technology for high-rate data transmission (multi-gigabit per second) for deep space and near-earth communications systems. It will also continue efforts to stimulate the competitiveness of the U. S. satellite communications industry by developing standards, protocols, and interoperability among space and terrestrial networks.

Focused Programs are dedicated to high-priority technologies needed for specific science missions. These can encompass developments from basic research all the way to infusion into science missions. Focused Programs also includes mission studies, which is the first phase of the flight program development process. Scientists work collaboratively with technologists and mission designers to develop the most effective alignment of technology development programs with future missions. This collaboration enables intelligent technology investment decisions through detailed analysis of the trade-offs between design considerations and cost. In order to ensure that the decisions resulting from mission studies are realistic and can be implemented, the studies will employ new techniques for integrated design and rapid prototyping.

The FY 1999 budget estimate includes four categories of activities under focused programs: these categories correspond to the four scientific themes of the Space Science Enterprise: Astronomical Search for Origins, Advanced Deep Space System Development (Solar System Exploration), Sun-Earth Connections, and Structure and Evolution of the Universe. These elements are described below:

- Astronomical Search for Origins Technology develops critical technologies for studies of the early universe and of extra-solar planetary systems. Included are large lightweight deployable structures, precision metrology, vibration isolation and structural quieting systems, optical delay lines and large lightweight optics. Missions supported in this area include the Space Interferometry Mission (SIM), Next Generation Space Telescope (NGST),and Terrestrial Planet Finder (TPF), as well as the provision of interferometry capability to the ground-based Keck telescopes..

- Advanced Deep Space Systems Technology provides for the development, integration, and testing of revolutionary technologies for solar system exploration. Emphasis will be on micro-avionics, autonomy, computing technologies, and advanced power systems. Funding in this area supports a Europa orbiter mission with a launch date in 2003, and a potential Pluto/Kuiper Express mission.

- Sun-Earth Connections Technology develops the technologies necessary for missions focused on observing the Sun and the effects of solar phenomena on the space environment and on the earth.

- Structure and Evolution of the Universe provides for the development of technologies to study the large scale structure of the universe, including the Milky Way and objects of extreme physical conditions: to explain the cycles of matter and energy in the evolving universe: to examine the ultimate limits of gravity and energy in the universe: and to forecast our cosmic destiny.

Flight Validation Program (often referred to as the New Millennium Program) completes the technology development process by validating technologies in space. While New Millennium missions are driven by needs for technology flight validation, they are also designed to return high priority science data within cost and mission constraints. Current plans reflect technology demonstration missions occurring at an approximate rate of one every 18-24 months. A key feature of this program is that industry-government partnerships are used to identify technology candidates, complete their development, and select them for flight validation. Through this process, high-value technology missions are made available for use in the Space Science program without imposing undue cost and risk on individual science missions. The New Millennium Program is funded by both the Space Science Enterprise and the Earth Science Enterprise.

The Space Science Research and Analysis Program carries out its goals and objectives by providing grants to universities, nonprofit and industrial research institutions, as well as by funding scientists at NASA Field Centers and other government agencies. Approximately 1,500 grants are awarded each year after a rigorous peer review process: only about one out of four proposals is accepted for funding. This scientific research is the foundation of the Space Science Enterprise. Key research activities include the analysis and interpretation of results from current and past missions; synthesis of these analyses with related airborne, suborbital, and ground-based observations: and the development of theory, the yields the scientific questions to motivate subsequent missions. The publication and dissemination of the results of new missions to scientists and the world is another key element of the Research and Analysis Program strategy, since it both inspires and enables cutting-edge research into the fundamental questions that form the core of the mission of the Space Science Enterprise.

MEASURES OF PERFORMANCE

Technology Program

Space Science Technology

X-2000 Testbed design Plan: 4th Qtr FY 1999	First delivery of an integrated and tested spacecraft avionics testbed design.
X-2000, CISM, *ARPS* Plan: 4th Qtr. FY 2000	First delivery of advanced avionics and power sources engineering models.
Develop CISM Curriculum Plan: 4th Qtr. FY 1998	Develop university curriculum for two CISM technology thrust efforts: Systems on a Chip, and Revolutionary Computing Technologies.
First Generation computing testbed Plan: 2nd Qtr FY 1999	Install first generation scaleable embedded computing testbed operating at 30-200 MOPS/watt.

Demonstrate scaleable computer for spaceborne applications Plan: 3rd Qtr. FY 1999	Demonstrate scaleable spaceborne applications on first-generation embedded computing testbed.

Cross-Enterprise Technology

Demonstrate optimized infrared detector array for astronomy and planet detection Plan: 3rd Qtr. FY 97 Actual: 3rd Qtr. FY 97	The array is a 256x256-element, impurity-band conduction (IBC), arsenic-doped-silicon (Si:As) device. This technology supports missions that require high-performance, cryogenically-cooled detector arrays at wavelengths near 40 microns.
Flight demonstrate a micro-gyroscope with control electronics. Plan: 4‘” Qtr. FY 97 Actual: 4th Qtr. FY 97	A microgyroscope with 10 degrees-per-hour drift rate was demonstrated on a DC-8 flight. This technology supports control and guidance systems for micro-spacecraft, landers, and rovers.
Develop small advanced monopropellant rocket Plan: 4th Qtr. FY 97 Actual: 4th Qtr. FY 97	A nontoxic monopropellant chemical system with 25% greater performance than current systems has been developed to support small satellite missions.
Demonstrate advanced Ni-Hydrogen battery Plan: 4‘”Qtr. 1997 Actual: 4th Qtr. FY 97	This battery will deliver 100 watts per kilogram and have a 10-year life in LEO, approximately twice the performance of current batteries.
Mars Pathfinder micro-rover operated on surface of Mars Plan: 3rd Qtr. FY 1997 Actual: 4th Qtr. FY 1997	The first mobile exploration robot to be flown to another planet, the “Sojourner” micro-rover has paved the way for future planetary exploration missions utilizing small rover systems.

Reduce size and weight of a communication system by a factor of 2-3. Plan: 4th Qtr. FY 97 Actual: 4th Qtr. FY 97	Reductions were achieved by integrating an advanced, space-based 20-Ghz phased-array antenna system in a communications network.
Complete the design (PDR) of a 20-GHz System-Level Integrated Circuit (SLIC)/Monolithic Microwave Integrated Circuit (MMIC)4-element phased array antenna system 622 MBPS data rate Plan: September 1997 Actual: : August 1997	This work will support the satellite industry in developing less expensive satellite antennas. By developing the phased array antenna the power and weight requirements would be reduced, allowing significant increases in spacecraft capability or reduced launch costs. In either case, the competitiveness of the commercial satellite industry would be enhanced.
Develop a small advanced monopropellant rocket Plan: 4th Qtr. FY 98	Fabricate and test flight-type nontoxic monopropellant system developed in FY 97.
Demonstrate 25% efficient production-quality solar cells Plan: 4th Qtr. FY 98	Pilot production of these efficient, new multi-band gap, large format solar cells will be done in FY 98.
Conduct AERcam/Sprint flight experiment Plan: 1st Qtr. FY 98 Actual: 1st Qtr. FY 98	This low-cost, free-flying robotic camera demonstrated remote visualization of EVA worksites, with applicability to International Space Station and other orbital spacecraft
Develop wide-band low-power electronically-tuned local oscillator sources up to 1.3THz Plan: 3rd Qtr. FY 98	This technology supports planned astronomy missions such as the Far Infrared Space Telescope (FIRST) mission to spectroscopically measure the chemical make-up of interstellar gases and nebulae.
Conduct on-orbit Ranger telerobotic flight experiment Plan: 4th Qtr. FY 99	This experiment, reconfigured to fly aboard STS-107, will demonstrate multiple on-orbit robotic servicing capabilities relevant to science payload servicing and Space Station assembly and maintenance.

Focused Programs

Space Interferometry Mission (SIM) Plan: 2nd-4th Qtr. FY 1999	Continue Phase B activities and conduct the preliminary non-advocate review of the high precision astrometry and synthetic aperture imaging technologies for space-based interferometers. Key features include 7 siderostats on a 1O-meter baseline and 10-milli-arcsecond synthesized imaging.
KECK Interferometer Optics Telescopes Plan: 1st Qtr. FY 1999	Initiate the Announcement of Opportunity for the build of 2-4 two-meter outrigger telescopes.
Solar System Exploration (non-Mars) First mission C/D start Plan: 1st Qtr. FY 2000	Complete mission concept development and begin development of Europa Orbiter, the first outer planetary mission.
X2003 "Flight-Like" Model Demo Plan: 2003	Testbed demonstration of X2003, the second integrated advanced spacecraft system. Requires a major fraction of electronic functions to be performed on a small number of multi-chip modules.
"Spacecraft-on-a-Chip" Plan: 2006	Testbed demonstration of integrated advanced spacecraft system in which all electronic functions are performed on chips. Incorporates all advanced electronic and power technologies along with CISM-developed novel computing concepts.
Complete phase B and transition to detailed design for Solar-B instruments Plan: 4th Qtr. FY 1999	Complete concept development for focal plane instrumentation for the optical telescope and X-ray telescope.
FIRST Composite Mirror Plan: 4th Qtr. FY 1998	Demonstrate 2-meter class composite mirror with less than or equal to 2.4 micron RMS surface.
FIRST Technology Development Plan: 4th Qtr. FY 1999	Develop Key Technologies in the area of cryo coolers, mixers, bolometer arrays, and light weight 3.5 m telescope to prepare for C/D start in FY 2000 and launch in FY 2006.
Release RFP for GLAST Technology Development Plan: 2"Qtr FY 1998	Release RFP for critical technology for tracker, anticoincidence shield, calorimeter, and data acquisition subsystems

Release RFP for Constellation X-ray Technology Development Plan: 2nd Qtr. FY 1998	Release RFP for critical technology development for hard X-ray telescope, Charge Coupled Device (CCD)/grating, and X-ray calorimeter
STEREO: Complete Concept Definitions Plan: 4th Qtr. FY 1999	Complete preliminary concept definitions for spacecraft systems and instruments through peer reviewed NRAs.

Flight Validation (New Millennium Program)

Deep Space 1

DS 1 Start of ATLO Plan: June 1997 Actual: August 1997	Start assembly, test, and launch operations of DS 1. Slight slip in schedule.
DS 1 Short S/C Environment Test Plan: December 1997 Actual: December 1997	Confirm that spacecraft can tolerate the launch and mission environments that it will face. On schedule.
DS 1 Ship to KSC Plan: April 1998	Ship to KSC launch site. On schedule
DS 1 Launch Plan: July 1998	First New Millennium technology demonstration flight. On schedule.

Deep Space 2

DS 2 Project Review #2 Plan: March 1997 Actual: March 1997	Detailed system level design and technologies identified. Completed on schedule.
DS 2 System Integration Test Plan: November 1997 Actual: November 1997	System integration and test in preparation for launch.

DS 2 Ship TMM for Environmental Test Plan: January 1998	Ship thermal mass model for environmental testing with the Mars Surveyor 98 Lander Cruise Stage Spacecraft.
DS 2 Probe Ship to KSC Plan: October 1998	Probe will be shipped to KSC for integration with Mars 98 Lander. On schedule
Launch DS 2 Plan: January 1999	Piggyback on Mars 98 Lander. On schedule.

Deep Space *3*

DS *3* Project Start Plan: October 1997 Revised: January 1998	Begin Phase A.
DS *3* Launch Plan: December 2001	Launch

Space Science Research and Analysis

Issue NASA Research Announcement (NRA) Plan: February 1998	This OSS NRA for Research Opportunities in Space Science (ROSS) solicits proposals for basic SR&T investigations to seek to understand natural space phenomena and space related technologies across the full range of space science programs relevant to the four OSS science themes. Participation in this program is open to all categories of U. S. and non-U. S. organizations including educational institutions, industry, nonprofit institutions, NASA Centers, and other Government agencies. Minority and disadvantaged institutions are particularly encouraged to apply. Recommendations for funding will be based on the evaluation of each proposal's science and technical merits, and its relevance to the OSS objectives as described in the **NRA.**

ACCOMPLISHMENTS AND PLANS

Technologv Program

The Explorer Technology initiative will identify, develop, infuse and transfer technologies that enable and enhance opportunities for frequent scientific investigations at the highest science value per unit cost. Procurement of the RAD6000 microprocessor chip in a multi-chip module format will enable a command and data handling "In Your Palm" Chip-on-Board technology demonstration to be incorporated in future SMEX missions.

The Advanced Radioisotope Power Source (ARPS) activity will begin to develop a robust high-efficiency, low-mass, low-cost 100-watt-class electrical power source for deep space missions in FY 1998, and will develop advanced technologies for radioisotope power sources in the milliwatt and 10-watt class for future science missions. This activity, performed in partnership with NASA/JPL, and the Department of Energy (DoE) will increase the efficiency of thermal to electric converters: reduce the cost and time to fabricate, test and deliver flight ARPS for deep space missions; and provide breakthrough technology and/or multifunctional radioisotope power sources for future microspacecraft.

Beginning in FY 1998, the Center for Integrated Space Microsystems (CISM) will develop the advanced computing and avionics technologies that will enable miniaturized autonomous robotic spacecraft for deep-space exploration. These technologies will comprise the core of the advanced spacecraft development. A world-class facility for microelectronics system design, advanced simulation, rapid prototyping, and integration and test will be established at JPL in FY 1999. This facility will be electronically linked to industrial partners and collaborating universities as part of the distributed Collaborative Engineering Workbench technology.

The Information Systems program will continue to provide reliable access for research communities and the public to obtain science data through the Planetary Data System, National Space Science Data Center, Space Telescope Science Institute, and High Energy Astrophysics Science Archive Research Center. Continuing advances in development and infusion of evolving information technology will increase the level of interoperability to support interdisciplinary research. Under High Performance Computing and Communication, the Remote Exploration and Experimentation project will continue to support the development of first generation testbed for scaleable spaceborne applications as well as embedded scaleable high performance computers.

Cross-Enterprise Technology

Activities within the Cross-Enterprise Technology program continue to focus on reducing spacecraft size, weight, and operating costs.

In the spacecraft systems technology area, accomplishments include demonstration of an advanced ion thruster system to reduce the mass of on-board propulsion systems by a factor of three; demonstration of a pulsed plasma thruster for miniature spacecraft: and demonstration of 25% efficient solar cells, 40% greater than the best available cells today. Both advanced integrated microelectronics and micro-devices (e.g. MEMS) will receive greater support leading to the eventual demonstration of fully integrated microspacecraft for deep space, planetary and earth-orbiting applications in FY 1999. Additional significant spacecraft system accomplishments will include: demonstration of a flight-type, clean, monopropellant thruster to replace hydrazine systems and deliver 25% higher performance and 50% lower operating cost: and initial demonstration of a combined energy storage/attitude control flywheel system with greater than an order-of-magnitude improvement over the state-of-the-art in system-level watt-hours/kg. Also within this budget, NASA is continuing the analysis of technologies and systems concepts identified in the 1996 "Fresh Look" study of space solar power. Future funding for space solar power activities will be contingent upon the results of this analysis and will seek to leverage ongoing NASA technology efforts.

Instrument/sensing technology will continue to focus on expanded spectrum performance and micro-miniaturization for both earth and space science. The development of sensor and instrument technology for compact, low-cost space radar systems continued in FY 1997 with the goal of enabling a low-cost flight demonstration of lightweight synthetic aperture radar technology. Other accomplishments include completion of the technology testbed for an advanced infrared telescope to validate new technology for use by future infrared astronomy and planet detection missions. This technology can reduce the size and cost of such a telescope by at least half while increasing performance.

In the area of Autonomy and Information Management, guidance/navigation algorithms are being validated for autonomous cruise and maneuver control. A complete 3-D stacked, multi-module architecture that is 10-times smaller than current spacecraft avionics systems is being demonstrated. Support will continue for a set of Regional Validation Centers (RVCs) which will evaluate our capability to enable a massive increase in the number of users of earth-sensing satellite data. An advanced suite of artificial intelligence tools for data fusion, mining, analysis and visualization will be provided in FY 1999. Methods for increasing the autonomy of satellites by doing on-board science data operations will be demonstrated in FY 1999.

In 1997, NASA conducted operations of the 10-kilogram (kg) Sojourner microrover on Mars as part of the Mars Pathfinder mission. The rover provided images of the lander to assess its condition on the planet's surface: used an alpha-proton-X-ray spectrometer to determine the composition of rocks and soil samples: and conducted multiple technology experiments to lead the way for routine use of small rovers to explore Mars. The program also continued development of the next generation of planetary surface micro-rovers, targeting a 50% reduction in rover mass and volume relative to Sojourner, as well as development of technologies for planetary and small body sample collection, preservation and autonomous analysis by FY 1998.

Also in FY 1997, the telerobotics program delivered the AERCam/Sprint flight experiment, a robotic "flying eye" for visualization and inspection of science and Space Station payloads, in preparation for its flight in FY 1998. This system demonstrates the use of advanced robotics technology to reduce EVA astronaut requirements for science payload servicing, and represents the first in a series of cooperative human EVA/robotic systems to be developed for on-orbit servicing operations. In FY 1999 the Ranger telerobotic technology experiment will be completed and delivered to KSC for integration into the Space Shuttle cargo bay for flight in early FY 2000. This redesigned experiment, in the new STS-compatible configuration, will demonstrate multiple advanced robotics technologies, including advanced ground control, autonomous operations, telepresence control, low-cost manipulator systems, and robotic servicing technologies. Also in FY 1999, the program will conduct testing of planetary rover systems with 10Km range, designed for long-lived (greater than one year) operations in planetary environments with minimal operator intervention.

In the Communications technology area, NASA and industry worked together in FY 1997 to demonstrate wide-band communications integrating space and terrestrial systems. Standards, protocols and interoperability for a world-wide, seamless multimedia network were developed and demonstrated. The wide-band-capable new terminals supported the first real-time, live transmissions of telescience, tele-education and remote sensing information. Technology demonstrations were completed for aeronautical and maritime, high-data-rate communications which enable communications at a rate about 10 times greater than is possible today. In FY 1998, NASA will take the lead in establishing a testbed to address the problems in developing seamlessly interoperable satellite and terrestrial networks. This testbed will be a continuation and expansion of NASA's effort to demonstrate hybrid networks operating at 155 million bits per second. In FY 1999, experiments will continue to demonstrate the applicability and compatibility of satellite systems with terrestrial fiber and wireless networks for the Global Information Infrastructure (GII) in the G-7 Global Interoperability of Broadband Network (GIBN) project. Several of those experiments will be using international networks and will require cooperation with other nations. Additionally, the program will continue to focus more on spacecraft needs, including the completion of the optical communications demonstrator (OCD), providing optical communications at data rates of 325 million bits per second. Success of this technology will enable scientific data transmission at rates 10-100 times greater than what is available today. The program will also provide technology development for miniaturized communications systems for spacecraft. This would include the development of miniaturized antennas for both spacecraft and rover applications.

Focused Programs

The Astronomical Search for Origins focused program will fund mission design and technology development for four elements in FY 1998 and 1999:

- Space Interferometer Mission (SIM) will be the world's first long-baseline operational optical space interferometer. It is scheduled for launch in mid-calendar year 2005, assuming successful technology development. This mission has dual objectives: science and technology. The science objectives include astrometric detection of planets around other stars in our galaxy (mostly those of Uranus' mass but also some as small as several earth masses), and precision location of even dim stars to an unprecedented accuracy: SIM will be a factor of 250 better in accuracy on stars 1000-times fainter than the best catalog currently available. The technology objective is to serve as the precursor to the future interferometry-based TPF mission. Specific technologies to be developed include precision laser metrology, controlled optics, optical delay lines, vibration isolation and structural quieting systems, and deployable structures.

- Next Generation Space Telescope (NGST) will combine large aperture and low temperature in an ideal infrared observing environment. NGST will allow astronomers to study the first protogalaxies, the first star clusters as they make their first generation of stars, and the first supernovae as they release heavy chemical elements into the interstellar gas. New technologies include precision-deployable structures, very large, low-area-density cold mirrors and active optics, and low-noise, large format infrared detectors. The target launch date is FY 2007.

- Keck Interferometer enables NASA to capitalize on its significant previous investment in the Keck Observatory in Hawaii by connecting Keck's twin 10-meter telescopes into an 85-meter-baseline interferometer. At the time of its completion in FY 2000, the Keck interferometer will become the world's most powerful ground optical instrument. Keck will be able to directly detect hot planets with Jupiter-size masses and will also be able to characterize clouds of dust and gases permeating other planetary systems,

- Terrestrial Planet Finder (TPF) is aimed at the ultimate goal of the NASA's Origins program: to find earth-like planets. Each of the precursor Origins activities, including the Space Infrared Telescope Facility (SIRTF), provides knowledge and technology needed for the design of the TPF. As currently envisioned, TPF will either be a large single-spacecraft interferometer or a group of several spacecraft (possibly copies of NGST) flown in precise formation. Thus, the experience and understanding gained in each step of the Origins program will be needed to make TPF successful. The current Phase C/D start is FY 2006 with a projected launch date of FY 2011.

The Advanced Deep Space Systems focused program will continue to provide for the development, integration, and testing of revolutionary technologies for solar system and outer planetary exploration in FY 1998-1999. Mission planning will support design and definition of the Europa Orbiter mission, targeted for launch in FY 2003, as well as a possible Pluto/Kuiper Express mission. Key technology partnerships will be maintained with national laboratories and research agencies such as: Air Force Research Labs to develop radiation-hard microelectronics technology; Sandia and Los Alamos National Laboratory to support MEMS, and ARPS technology; MIT Lincoln Labs to continue Advanced Semiconductor technology; and DARPA to continue ultra-scale computing and quantum computing technology. Emphasis on micro-avionics, autonomy, computing technologies, and advanced power systems will be maintained to support Europa Orbiter and a possible Pluto/Kuiper Express mission.

The focus for Sun-Earth Connections mission planning and technology activities will be directed toward the following future missions:

- Solar Probe, the first close fly-by of a star (within 4 solar radii), requires a thermal shield to protect the payload from the Sun without releasing material that would contaminate the in-situ measurements. It also requires radiation hardening for the Jupiter swing-by and fly-by the Sun. The target launch date is awaiting mission review and approval.

- Solar-B, a joint mission with the Japanese (ISAS spacecraft and launch), requires lightweight, stable optics and high-accuracy polarimetry for high-resolution (~0.1arc sec) measurements of solar magnetic fields. Solar-B's expected launch date is FY 2004.

- STEREO is conceived as two smallsats in solar orbit to provide stereo imaging of solar corona, to track solar mass ejections from the Sun to Earth using radio and optical instruments, and to measure in-situ the solar wind and energetic particles (solar mass ejections appear to be a primary source of intense solar energetic particles events) with an anticipated launch date of FY 2005.

- Magnetospheric Multiscale is to be comprised of six spacecraft (four for in-situ measurements, two for global imaging) to study simultaneously the global behavior of the magnetosphere and the magnetospheric processes at the small scales where many of the basic interactions occur. The target launch date is FY 2006.

- Global Electrodynamics is a mission made up of five spacecraft, which will have an "atmospheric dipping" capability for investigating the electromagnetic coupling between the solar wind and upper atmosphere. The target launch date is FY 2008.

- Magnetospheric Constellation will support a fleet of 10-100 microsats using radio tomography and in-situ instrumentation to provide instantaneous global maps of plasma and field structures in the magnetosphere. The target launch date is FY 2010.

Structure and Evolution of the Universe mission planning and technology activities focus on development and demonstration of technologies necessary to implement the space missions outlined in the recent SEU Science and Technology Roadmaps. The priority missions include:

- Gamma Ray Large Area Space Telescope (GLAST). GLAST will study cosmic sources of high-energy particles and radiation (up to 300 GeV) with a large area, wide field-of-view, imaging telescope, using solid-state particle tracking technology.

- Constellation X-ray Mission. Constellation will use multiple satellites to enable a very large collecting area. Each spacecraft will be equipped with a high throughput telescope for the low energy band up to 10 keV, and three grazing-incidence telescopes for the high energy band.

- ESA's Far Infrared and Submillimeter Space Telescope (FIRST). The U. S. participation on the FIRST mission substantially enhances the science goals with four key technologies - lightweight telescopes, cryocoolers, bolometer arrays, and heterodyne receivers.

Flight Validation (New Millennium Program)

The principle activities in FY 1997 included the completion of DS 1 spacecraft fabrication and assembly, as well as the integration and test of the new subsystem technologies associated with the mission. The majority of early analysis and test for DS 2 was completed and fabrication of flight hardware has started. In addition, initial concept definition was undertaken in FY 1997 on the **DS-3** and DS-4 missions.

The principle mission-related activities in FY 1998 will include the completion of environmental and system testing and DS 1 launch in July; and fabrication and start of Assembly, Test, and Launch Operations (ATLO) of DS 2. The DS 2 will piggyback on Mars 98 Lander, which is scheduled to launch in January, 1999 Definition of the DS-3 and DS-4 missions is expected to continue in FY 1998, with approval to proceed anticipated for at least one new mission by the end of the year. FY 1999 funds will support development of any missions selected, as well as concept definition for additional future missions.

Following some cost growth from the initial cost estimates provided previously, the DS 1 and DS 2 missions have been capped at $141.1M and $26.5 M, respectively.

<u>Space Science Research and Analvsis</u>

NASA's R&A program continued to produce exciting scientific results in FY 1997. Over the past decade, the scientific community has come to realize that life outside of Earth is probable considering that: (1)life exists on Earth wherever there is liquid water; (2) life appeared very quickly on early Earth: and (3)early Mars had an environment similar to early Earth. In response to the exciting findings that galvanized scientific and public interest, NASA and NSF initiated a special meteorite analysis program concerning Martian meteorites, specifically ALH8400 1. The goal is to confirm or refute the purported evidence of Martian life and to recognize the limits of knowledge of what may be learned from Mars meteorites.

Life is most probably a natural consequence of the physical and chemical processes in the universe. In recognition of the interrelationship between the origin and evolution of life and the origin and evolution of planets, a new program within the framework of Astrobiology was initiated in 1997. The program will focus on biological research on the evolution of life on earth to anticipate the likelihood and nature of life elsewhere in the universe. Furthermore, an Astrobiology Institute will be established in FY 1998 with the selection of openly competed interdisciplinary research teams. The "virtual" Institute will foster interdisciplinary research among geographically dispersed laboratories using the Next Generation Internet.

Balloon-borne programs offer scientifically compelling results at a fraction of the cost of satellite missions for some specific types of observations. For example, the R&A program supports balloon-based studies of the cosmic background emission at sensitivities which will exceed that of the historic Cosmic Background Explorer (COBE). Furthermore, observations at smaller angular scales will reveal characteristic structure of the cosmos which will significantly constrain the values of three major "cosmological constants," including the early rate of universal expansion and the mass density of the universe.

Balloon exposures of high energy particle detectors are searching for antimatter, performing studies of nuclear isotopes at relativistic energies beyond the reach of the Advanced Composition Explorer (ACE)launched in August, 1997, and testing the theories of supernova stock acceleration by making nuclear composition measurements at energies beyond 10-GeV.

The Suborbital Program in Magnetospheric, Ionospheric, Thermospheric, and Mesospheric (MITM) physics continues its critical support of MITM programs through its provision of fast, inexpensive access to space. Analysis of previously obtained aircraft-based data has, for instance, provided significant insight into the physical mechanisms underlying sprites and other newly-discovered thunderstorm-associated phenomena. Balloon-based studies of sprite electric fields, critical but currently unknown quantities, are being planned for the summer of 1998. Work is also beginning on a sounding rocket investigation which will provide, in the winter of 1998/ 1999, the first flight test of JPL's hockey-puck-sized Free Flying Magnetometers.

Through joint funding with NSF, scientists throughout the country are continuing to observe, analyze and publish the results of encounters with two bright exciting comets which were in our sky this year, Comets Hale-Bopp and Hyakutake. New instrumentation not available in earlier years has allowed us to observe these two events in a wide range of wavelengths from the X-ray region to radio wavelengths. The results of these observations should provide a far better understanding of the composition and history of comets, which in turn may modify our picture of the early solar system.

The FY 1998 estimates for grants-based programs (including R&A and MO&DA) have been adjusted to allow $50 million in funding ($38.1 million in R&A and $11.9 million in MO&DA) to be potentially applied to Space Station, depending on the outcome of future appropriation action. This funding is made available by changes in the process of awarding and renewing research grants, which will allow reductions in these grants-based programs with no effect on the level of activity.

BASIS OF FY 1999 FUNDING REQUIREMENT

SUBORBITAL PROGRAM

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Stratospheric Observatory for Infrared Astronomy	21,300	45,800	56,500
[Construction of Facilities]			15,6001
Balloon program	14,000	13,700	13,500
Sounding rockets	24,600	23,800	29,600
Total	59,900	83,300	99,600

PROGRAM GOALS

The principal goal of the Suborbital program is to provide frequent, low-cost flight opportunities for space science researchers to fly payloads to conduct research of the earth's ionosphere and magnetosphere, space plasma physics, astronomy, and high energy astrophysics. The program also serves as a technology testbed for instruments which may ultimately fly aboard orbital spacecraft, thus reducing cost and technical risks associated with the development of future space science missions. It is also the primary program for training graduate students and young scientists in hands-on research techniques.

STRATEGY FOR ACHIEVING GOALS

The Suborbital program provides the science community with a variety of options for the acquisition of in-situ or remote sensing data. Aircraft, balloons and sounding rockets provide access to the upper limits of the earth's atmosphere. The Spartan program, funded within the Sounding Rocket budget element at a level of approximately $1.5 million per year, provides access to space by supporting deployable payloads for flight aboard the Shuttle. Activities are conducted on both a national and international cooperative basis.

Astronomical research with instrumented jet aircraft has been an integral part of the NASA Physics and Astronomy program since 1965. For relatively low-cost, NASA has been able to provide to the science community very quick, global response to astronomical "targets of opportunity." The Stratospheric Observatory For Infrared Astronomy (SOFIA) is a new airborne observatory designed to replace the retired Kuiper Airborne Observatory (KAO). SOFIA consists of a 2.5m telescope provided by the German Aerospace Center (DLR) integrated into a modified Boeing 747 aircraft. With spatial resolution and sensitivity far superior to the KAO, SOFIA will facilitate significant advances in the study of a wide variety of astronomical objects, including regions of star and planet formation in the Milky Way, activity in the nucleus of the Milky Way, and planets, moons, asteroids and comets in our solar system'. The program will build upon a very successful program of flying teachers on the KAO by reaching out to K-12 teachers as well as science museums and planetaria around the country.

KAO operations were terminated in October 1995; the savings from cessation of KAO operations are an integral element of the funding plan for SOFIA. Development of SOFIA started in FY 1997. In December 1996, NASA selected a team led by the Universities Space Research Association (USRA), Columbia, MD, to acquire, develop and operate SOFIA. The Cost-Plus-Incentive and Award Fee-type contract has a base period for development plus one five-year operations cycle. The contract also contains an option period for one additional five-year operations cycle. SOFIA is expected to be operated for at least 20 years. The contract will be managed by NASA's Ames Research Center, Mountain View, CA. Other team members include Raytheon E-Systems - Waco, TX (formerly CTAS); United Airlines, San Francisco: an alliance of the Astronomical Society of the Pacific and The SETI Institute, both of Mountain View, CA; Sterling Software, Redwood City, CA: and the University of California at Berkeley and Los Angeles. The contract calls for the selected company to acquire an existing Boeing 747 SP aircraft, design and implement a modification program to accommodate installation of a large infrared telescope, test and deliver the flying astronomical observatory to NASA, and provide mission and operations support in approximately five-year increments. USRA's proposal calls for operating the aircraft out of Moffett Federal Airfield, Mountain View, CA, with initial operations starting October 2001. SOFIA funding includes $5.6 million in FY 1999 Construction of Facilities funds for modification of SOFIA ground support facilities at Ames Research Center.

The Balloon program provides a cost-effective way to test flight instrumentation in the space radiation environment and to make observations at altitudes above most of the water vapor in the atmosphere. In many instances, it is necessary to fly primary scientific experiments on balloons, due to size, weight, cost considerations or lack of other opportunities. Balloon experiments are particularly useful for infrared, gamma-ray, and cosmic-ray astronomy. In addition to the level-of-effort science observations, the program has successfully developed balloons capable of lifting payloads greater than 5000 pounds. Balloons are now also capable of conducting a limited number of missions lasting 9 to 24 days, and successful long-duration flights are being conducted in or near both polar regions. The Balloon program is managed by the GSFC Wallops Flight Facility (WFF). Flight operations are conducted by the National Scientific Balloon Facility (NSBF), a government-owned, contractor-operated facility in Palestine, Texas.

Analytical tools have been developed to predict balloon performance and flight conditions. These tools are being employed to analyze new balloon materials in order to develop an advanced long-duration program based on superpressure balloons. The balloon operations at NSBF are being re-competed as a performance based, government-owned contractor operated activity.

Sounding rockets are uniquely suited for performing low-altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters. Special areas of study supported by the sounding rocket program include: the nature, characteristics and composition of the magnetosphere and near space; the effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurora and the coupling of energy into the atmosphere; and the nature, characteristics and spectra of radiation of the Sun, stars and other celestial objects. In addition, the sounding rocket program allows several science disciplines to flight test instruments and experiments being developed for future flight missions. The program also provides a means for calibrating flight instruments and obtaining vertical atmospheric profiles to complement data obtained from orbiting spacecraft. The program is managed by GSFC/WFF, and launch operations are conducted from facilities at WFF, Virginia; White Sands, New Mexico; and Poker Flat, Alaska, as well as occasional foreign locations.

The sounding rocket program is currently in the midst of restructuring. The intent is to compete a procurement that will allow the government to transition away from operational control and move toward a contracted operation with performance-based attributes. Award of a contract is currently envisioned by fourth quarter, FY 1998.

In an effort to broaden the education opportunities using experiments built by students and flown on suborbital rockets and stratospheric balloons, a Student Launch Program has been established for U. S. institutions of higher learning. This program offers students for the bachelor's through master's degrees an opportunity to work on a reasonably complex project from its inception through to its end, in a timeframe tenable within their academic careers. A NASA Research Announcement released in June 1996 offered proposers up to $35,000 over 30 months or less for the design, construction, and flight of student-built balloon and/or sounding rocket experiments, including analysis of data. Six proposals were accepted during the proposal review in 1997. The selected experiments will be flown during 1998 and 1999.

The Spartan program provides reusable spacecraft which can be flown aboard the Shuttle. These units can be adapted to support a variety of science payloads and are deployed from the Shuttle cargo bay to conduct experiments for a short time (i.e. several hours or days). Payloads are later retrieved, reinstalled into the cargo bay and returned to earth. The science payload is returned to the mission scientists for data retrieval and possible refurbishment for a future flight opportunity. The Spartan carrier is also refurbished and modified as needed to accommodate the next science payload.

MEASURES OF PERFORMANCE

SOFIA Development

RFP Released Plan: February 1996 Actual: May 1996	Request for Proposals from industry for the SOFIA development and operations prime contract. Delayed in order to incorporate a variety of modifications arising out of the draft RFP.
NASA/DARA MOU signed Plan: April 1996 Actual: December 1996	Formal agreement between **NASA** and the German Space Agency on SOFIA. Delayed by resolution of various minor wording issues; no substantive issues.
Prime contract award Plan: August 1996 Actual: December 1996	Selection of the SOFIA development and operations prime contractor.
System Requirements Review Plan: October 1997 Actual: September 1997	Completed review of engineering technical requirements for the US SOFIA system elements.

US System Preliminary Design Review Plan: August 1998	Review of the U. S. contractor's concept for development and integration of the observatory. On schedule.
Telescope Assembly Critical Design Review Plan: November 1998	Formal review of the German contractor's concept for implementation of the telescope assembly. On schedule.

Balloon Program

FY 1997	28 flights were planned from Palestine, Texas, Fort Sumner, Canada, Alaska, and Brazil. 26 flights were attempted, and 25 missions flew successfully.
FY 1998	32 flights are planned,
FY 1999	Approximately 22 flights could be supported.

Sounding Rockets

FY 1997	26 flights were planned from four sites: WFF, WSMR, Alaska, and Norway. 29 actual flights were manifested, of which 28 were flight successes.
FY 1998	32 flights are planned, including 11 from Puerto Rico, 2 from Norway, and 2 from Svaalbard.
FY 1999	Approximately 22 sounding rocket flights could be supported.

Spartan

FY 1997	Preparing for the fourth flight of the Spartan 201 solar telescope.
FY 1998	Spartan 201-4 was deployed and retrieved on STS-87 in December 1998. Due to operational problems on this mission there was limited science return.
FY 1998	A reflight is being planned for the first quarter FY 1999.

ACCOMPLISHMENTS AND PLANS

The 747 SP aircraft for SOFIA was purchased in early 1997 and has undergone thorough inspection. Modifications to the vehicle will begin in mid-1998. The telescope will be integrated and tested by late in the year 2000, with science flights scheduled to begin in 2001. The international Memorandum of Understanding between NASA and DARA was also signed in December 1996. The contractors on both sides of the Atlantic will initiate final design work, heading toward Preliminary Design Reviews in March and April 1998 for the telescope assembly and the overall system, respectively.

In FY 1997, 28 sounding rockets and 25 balloons were flown. Additionally, the first long-duration balloon flight in the northern hemisphere was successfully conducted. This mission lasted more than 11 days, circumnavigating the globe just below the Arctic Circle, and it involved the cooperation of numerous countries which were overflown. This capability provides an alternative to Spacelab missions for some investigators, and is now being used in polar campaigns for solar investigations and to fly cosmic ray experiments. Technology development for superpressure ballooning has been initiated.

For FY 1998, 32 flights are planned for the sounding rocket program and 32 balloons will be launched. In FY 1999, 22 sounding rocket launches are anticipated and 22 balloons are expected to be flown. The NASA Sounding Rocket Operations Contract RFP is expected to be released in early February 1998, with contract award being made in September 1998. The Long Duration Balloon Project contract is expected to be awarded in late FY 1998 or early FY 1999. Reflight of Spartan 201-4 is planned for the first quarter of FY 1999.

BASIS OF FY 1999 FUNDING REQUIREMENT

AUN(SERVI

	FY 1997	FY 1998	ET 1999
	(Thousands of Dollars)		
Launch Services...	240,600	215,900	203,500

PROGRAM GOALS

To provide successful, on-time launch services for the Space Science missions at the least possible cost. Launch Services are a vital element in the achievement of the overall goals of the Space Science program.

STRATEGY FOR ACHIEVING GOALS

Payloads may be launched aboard a number of vehicles, each of which supports a discrete performance class. A contract for Ultra-Lite launch services was signed with OSC in December 1994 to support the STEDI and University-class Explorer (UNEX) program. This class of ELV will provide approximately one-half the lift capacity of a Pegasus.

Small payloads are launched aboard the Pegasus XL, which is provided by the Orbital Sciences Corporation (OSC) and requires in-flight deployment from a Lockheed L101 1 aircraft. The Pegasus XL is capable of delivering payloads up to approximately 1,000 pounds to low earth orbit.

The Med-Lite is class of launch services which is capable of delivering payloads up to 5,000 lbs to low-earth orbit. The Med-Lite contract was signed with McDonnell Douglas (now Boeing) in February 1996 and offers Taurus launch vehicles(to be manufactured by Orbital Science Corporation) and Delta launcher configurations with 3-4 strap-on solid rocket motors.

Medium class payloads utilize launch services capable of delivering up to 11,000 pounds to low earth orbit. These missions are launched aboard the Delta launch vehicle, which is provided by Boeing. These vehicles may be launched either from the Cape Canaveral Air Force Station (CCAFS) or, if a polar orbit is required, from the Vandenberg Air Force Base (VAFB).

Large class payloads requiring the delivery of up to 39,000 pounds to low-earth orbit are launched aboard the USAF -managed Titan IV/Centaur launch vehicle. NASA procured a Titan IV/Centaur launch vehicle for Cassini via an existing contract between the United States Air Force (USAF) and Lockheed-Martin Corporation (LM). A separate contract for mission unique integration activities was established directly between NASA and LM. NASA has no plans for additional Titan IV missions.

Payloads launched aboard the Shuttle may be delivered to a higher orbit via the use of an upper stage. The AXAF mission will be launched aboard the Shuttle, and will use an Inertial Upper Stage (IUS) manufactured by Boeing to deliver the spacecraft to a highly elliptical orbit.

MEASURES OF PERFORMANCE

Ultra-Lite Class Launch Vehicles

SNOE launch Plan: May 1997 Current: January 1998	Launch aboard a Pegasus launch vehicle. Schedule delayed due to Pegasus technical and manifest problems.
TERRIERS launch Plan: August 1997 Current: August 1998	Launch aboard a Pegasus launch vehicle. Schedule delayed due to Pegasus technical and manifest problems.
HETE-II launch Plan: October 1999	On schedule for launch aboard an Ultra-Lite class ELV / 1/2 Pegasus, co-manifested with OMTPE ACRM payload.

Small Class Launch Vehicles

SAC-B/HETE launch Plan: November 1996 Actual: November 1996	Dual payload launch from WFF aboard Pegasus XL/L1011 launch vehicle on November 4, 1996. The Pegasus vehicle failed to separate the two payloads from the third stage. Spacecraft are not functional.
SWAS launch Plan: TBD Current: January 1999	Delay has resulted from launch failure, and NASA decision to postpone launch until Pegasus corrective action plan completed.
TRACE launch Plan: October 1997 Current: March 1998	Delay due to a Pegasus launch failure and subsequent technical and manifest problems.
WIRE launch Plan: August 1998 Current: March 1999	Delay due to a Pegasus launch failure and subsequent technical and manifest problems. NASA is working to accelerate launch to meet September launch window.

Med-Lite Class Launch Vehicles

Deep Space 1 launch Plan: July 1998	On schedule for launch aboard a Delta 7326 launch vehicle.
FUSE launch Plan: October 1998	On schedule for launch aboard a Delta 7320 launch vehicle.
Mars 1998 Lander Plan: December 1998	On schedule for launch aboard a Delta 7325 launch vehicle.
Mars 1998 Orbiter Plan: January 1998	On schedule for launch aboard a Delta 7425 launch vehicle.
Stardust launch Plan: February 1999	On schedule for launch aboard a Delta 7426 launch vehicle.

Medium Class Launch Vehicles

Mars Global Surveyor launch Plan: November 1996 Actual: November 1996	Launched successfully aboard a Delta II launch vehicle on November 7, 1996.
Mars Pathfinder launch Plan: December 1996 Actual: December 1996	Launched successfully aboard a Delta II launch vehicle on December 4, 1996.
ACE launch Plan: September 1997 Actual: August 1997	Launched successfully aboard a Delta-11, D7925, on 8/25/97.

All Other Classes of Launch Vehicles:

Cassini launch Plan: October 1997 Actual: October 1997	Launched successfully on 10/15/97 on a Titan IV/Centaur

AXAF launch Plan: August 1998	Launch date on STS/IUS under review due to spacecraft delays during integration and test.

ACCOMPLISHMENTS AND PLANS

During FY 1997, three Space Science missions were launched successfully, with one unsuccessful launch attempt:

Mission	Launch Date	Vehicle	Status
SAC-B/HETE	11/14/96	Pegasus XL	Unsuccessful launched
Mars Global Surveyor	11/7/96	Delta-II	Launched successfully
Mars Pathfinder	12/4/96	Delta-II	Launch successfully
ACE	8/25/97	Delta-II	Launch successfully

During FY 1998, the Cassini mission launched successfully aboard a Titan IV/Centaur vehicle on October 15, 1997. OSS plans to launch another four missions during the remainder of FY 1998. The OSS missions that are planned for launch in FY 1998 are:

Mission	Launch Date	Vehicle	Status
Cassini	10/15/97	Titan IV/Centaur	Launched successfully
SNOE	1/98	Ultra-Lite (1/2 Pegasus XL)	On schedule
TERRIERS	8/98	Ultra-Lite (1/2 Pegasus XL)	On schedule
Deep Space 1	7/98	D-7326/Med-Lite	On schedule
AXAF	9/98	STS with an IUS	On schedule

OSS plans to launch eight missions during FY99:

Mission	Launch Date	Vehicle
CATSAT	3Q/99	Ultra-Lite (1/2 Pegasus XL)
SWAS	1/99	Pegasus XL
WIRE	9/98	Pegasus XL
FUSE	10/98	Delta-7320/Med-Lite
Mars '98 Orbiter	12/98	Delta-7325/Med-Lite
Mars '98 Lander	1/99	Delta-7425/Med-Lite
Deep Space 2	1/99	Piggyback with Mars '98 Lander
Stardust	2/99	Delta-7426/Med-Lite

FY 1998-1999 launch services funding will support the following future (post-FY 1999) launches:

- Ultra-light launch vehicles: HETE-II (10/99), UNEX-1 (4Q\99), and UNEX-2 (4Q/00)
- Small Explorer missions on small launch vehicles: HESSI/SMEX-6 (7/00), GALEX (9/01), and Deep Space *3* (6/01)
- Med-Lite launch vehicles: IMAGE (1/00) and *MAP* (11/00), Genesis (1/01), Contour (6/02), and Mars 2001 Orbiter (2/01) and Lander (4/0 1)
- Delta-II launch vehicles: TIMED (5/00), and Gravity Probe B (GP-B) (3/00)

In addition to the above missions, OSS ELV funding also provides for final payment to the United States Air Force (USAF) and Lockheed Martin Corporation (LM) for the Cassini Titan IV/Centaur launch vehicle. It also supports procurement of an Inertial Upper Stage (IUS) for the AXAF mission that will be launched aboard the Shuttle in August 1998.

Life and Microgravity
Sciences and
Applications

SCIENCE. AERONAUTICS AND TECHNOLOGY

FY 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars1			
Advanced human support technology program	19.700	17.900	24.500	SAT 2-7
[Construction of facilities]		[2,2001		
Biomedical research and countermeasures program	44.100	40.600	50.000	SAT 2-10
Gravitational biology and ecology program	33.600	30.000	37.100	SAT 2-14
Microgravity research program	105.300	100.400	106.700	SAT 2-19
Space product development program	13.000	12.900	14.400	SAT 2-28
Occupational health research function	200	700	700	SAT 2-33
Space medicine research function	3.600	6.800	6.900	SAT 2-36
Mission integration function.,..	24.200	4.900	1.700	SAT 2-39
Total	243.700	214.200	242.000	

Distribution of Program Amount bv Installation

	FY 1997	FY 1998	FY 1999
Johnson Space Center	51.000	43.700	67.400
Kennedy Space Center	6.800	6.300	3.400
Marshall Space Flight Center	53.800	54.400	63.300
Ames Research Center	31.200	24.100	30.200
Langley Research Center	2.000	400	200
Lewis Research Center	40.000	35.000	32.100
Goddard Space Flight Center	25.300	13.300	8.000
Jet Propulsion Laboratory	18.000	18.500	12.300
Headquarters	15.600	18.500	25.100
Total	243.700	214.200	242.000

GENERAL

Commencing with the FY 1999 Congressional Budget Submission, the Office of Life and Microgravity Sciences and Applications (OLMSA)budget structure has been realigned to reflect the reorganization of the programmatic activities into the five programs and three functions displayed below. This realignment supports the Agency's direction to transfer program management responsibilities from Headquarters to Lead Centers.

Prior Budget Categories	New Budget Categories	Lead Center
Life Sciences	Advanced Human Support Technology (AHST)Program	Johnson Space Center (JSC)
	Biomedical Research & Countermeasures (BR&C) Program	JSC
	Gravitational Biology and Ecology (GB&E) Program	Anies Research Center (ARC)
Microgravity Research	Microgravity Research (MR) Program	Marshall Space Flight Center (MSFC)
Space Product Developnierit	Space Product Development (SPD) Program	MSFC
Aerospace Medicine	Space Medicine Research (SMR) Function	JSC
	Occupational Health Research (OHR) Function	Kennedy Space Center (KSC)
STS/Spacelab Mission Management & Integration	Mission Iritegration (MI) Function	Headquarters (HQS)

The science components of the Space Station program -- the NASA-Mir Research Program, and Space Station Facilities and Utilization -- are under the management of the International Space Station (ISS) program as of FY 1998. The funding and budget justification for these activities is now included under the ISS budget justification.

PROGRAM GOALS

OLMSA is an integral element of NASA's Human Exploration and Developnient of Space Strategic Enterprise (HEDS). In collaboration with NASA's Office of Space Flight, and with support from the other Strategic Enterprises, OLMSA pursues the following HEDS Mission: *To open the Space Frontier by exploring, using and enabling the deuelopmeiit of space arid to expand the human experience into the far reaches of space.* HEDS pursues this mission through the following goals in partnership with the Office of Space Flight:

- Prepare to conduct human missions of exploration to planetary and other bodies in the Solar System
- Use the environment of space to expand scientific knowledge.

- Provide safe and affordable human access to space, a human presence in space, and share the human experience of being in space.
- Enable the commercial development of space and share HEDS knowledge, technologies, and assets that promise to enhance the quality of life on earth.

STRATEGY FOR ACHIEVING GOALS

OLMSA pursues the goals described above through the following programs which focus on specific fields of research:

Advanced Human Support Technology (AHST)
- Provides cutting edge technologies for the support of humans in space.

Biomedical Research and Countermeasures (BR&C)
- Promotes the health, safety and performance of space crews.
- Investigates the biomedical effects of space flight to provide the biomedical basis for future human exploration and development of space.

Gravitational Biology and Ecology (GB&E)
- Investigates the interaction between gravity and basic biological processes using living systems, ranging from simple cells to humans, in space and on the ground.

Microgravity Research (MR)
- Uses space as a laboratory to explore the nature of physical phenomena, contributing to progress in science and technology on earth.
- Studies the role of gravity in technological processes, building a scientific foundation for understanding the consequences of gravitational environments beyond earth's boundaries.

Space Product Development (SPD)
- Facilitates the use of space for commercial products and services.

Within each of these programs, OLMSA supports fundamental research driven by an emphasis on expanding scientific knowledge; mission driven research which improves knowledge and technology for human space flight and exploration; and applications driven research which seeks to transfer knowledge, expertise and technology to an appropriate partner or partners.

In addition, OLMSA is an operational organization conducting the following functions:

<u>Space Medicine Research (SMR)</u>

- Provides guidance to the operational medicine community at JSC for the delivery of clinical care in support of human space flight.
- Establishes requirements for medical care and medical research to support human space flight.

<u>Occupational Health Research (OHR)</u>

- Ensures health and safety of all NASA employees.

<u>Mission Integration (MI)</u>

- Integrates research missions involving human space flight.

Greater detail is provided below in a separate section on each of these programs and functions.

OLMSAs program of research and technology development relies upon broad participation by researchers from academia, from other government agencies and departments, from the commercial sector, and from NASA Field Centers. In selecting investigations and projects for support, and ultimately for access to space, OLMSA follows different, but closely related, processes for scientific research, for commercial research, and for technology research and development.

All non-commercial research, whether conducted by NASA employees, private sector researchers, or academic researchers, must pass through a rigorous peer review screening process. OLMSA does not employ a separate research selection track for mission oriented research. Such research, whether basic or applied, passes through a competitive peer-reviewed process. OLMSA does not generally solicit proposals on a mission-specific basis, but maintains a queue of worthy research which is funded as opportunities become available,

OLMSA implements its programs through ground-based research, research on uncrewed free-flying vehicles, Space Shuttle missions, research on the Russian Mir Space Station, and, in the future, on the ISS. OLMSA employs this array of platforms in support of the broader strategic goals enumerated above. Ground-based research generally precedes and validates the need for flight experiments.

While the FY 1998 funding level is below that of FY 1997 and FY 1999, it represents no significant reduction in program content (other than the planned completion of the Spacelab program). The reduced FY 1998 level is equivalent to the actual "buying power" (cost) available in FY 1997, and represents the agency's attempt to adjust Budget Authority levels consistent with the utilization of uncosted budget authority.

ENTERPRISE LEVEL PERFORMANCE MEASURES

OLMSA tracks three performance measures at the Strategic Enterprise level which are also included in the NASA Annual Performance Plan. Performance within each of OLMSA's five constituent programs and three functions is monitored based on program-specific performance measures.

Performance Measure: Effectiveness of Microgravity Countermeasures

Associated Enterprise Goals: Prepare to conduct human missions of exploration to planetary and other bodies in the Solar System; Provide safe and affordable human access to space, a human presence in space, and share the human experience of being in space.

Description: In order to conduct human exploration and to provide safe and affordable access and presence in space, we must understand and control the effects of microgravity on human health and function. Ongoing research and expanded experience, especially on the ISS, will help us improve astronaut performance and reduce the time required for astronauts to recover full functions following long-duration missions. OLMSA will track aggregate countermeasures effectiveness using two indices. Each index will include values ranging from one to five. The Post-flight Rehabilitation Index will be used to evaluate crew health on return to earth based upon the time it takes to rehabilitate and return to space flight duty status. A second rating scale will be based upon deviations from planned mission timelines which are caused by biomedical and/or environmental concerns. Values for both indices will be assigned and docuniented by HEDS for each crew-mission. Values will be reviewed by the Aerospace Medicine and Occupational Health Advisory Subcommittee of the NASA Advisory Committee. Average ratings will be reported for each fiscal year.

Performance Measure: Publications and Science Community Participation

Associated Enterprise Goals: Use the environment of space to expand scientific knowledge.

Description: Publications represent the immediate product of HEDS scientific research efforts. Those papers which are published in "peer reviewed" or "refereedjournals" have been selected for publication by cognizant experts on the basis of their contributions to the scientific knowledge base. Publications are the tangible manifestation of new scientific knowledge created by the HEDS enterprise.

Performance Measure: Mass Requirements for Life Support

Associated Enterprise Goals: Prepare to conduct human missions of exploration to planetary and other bodies in the Solar System Provide safe and affordable human access to space, a human presence in space, and share the human experience of being in space.

Description: The mass requirements of life support systems play a key role in determining the cost of human space flight. While there are many other technical parameters of concern (e.g. power consumption, reliability, cost of development, etc.), the mass requirements of life support systems serve as a good aggregate indicator of life support system performance.

BASIS OF FY 1999 FUNDING REQUIREMENT

ADVANCED HUMAN SUPPORT TECHNOLOGY PROGRAM

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Advanced Human Support Technology (AHST) Programi	19,700	17,900	24,500
[Construction of facilities]		[2,200]	

PROGRAM GOALS

The goals of the AHST programi are: (1) demonstrate and validate full self-sufficiency in air and food recycling technology for use in space vehicles: (2) demonstrate and validate integrated, fully autonomous environniental nionitoring and control systems; and *(3)* validate and incorporate human factors engineering technology and protocols to ensure maintenance of high ground and flight crew skills during long duration missions. The AHST program makes NASA technologies available to the private sector for earth applications.

STRATEGY FOR ACHIEVING GOALS

The AHST program includes advanced life support systems (ALS), space human factors (SHF), and advanced environmental monitoring and control (AEMC).

The ALS programi develops advanced regenerative life support technologies and systems by combining biological, physical, and chemical processes capable of producing and recycling the food, air, and water needed to enable long-term human missions in space in a safe and reliable manner while minimizing the need for resupply. Its projects and activities apply engineering and biological sciences to the design of technologies that support and control physical-chemical and bioregenerative closed loop systems for clean air and potable water. The program applies knowledge from the biological sciences to develop technologies for growing, harvesting, and processing crop plants for flight crew consumption.

SHF works to expand knowledge of human psychological and physical capabilities and limitations in space. It develops technologies that integrate the human and system elements of space flight. It encourages mission planners to use human factors research results and technology developments to improve mission results and crew safety.

The primary emphasis of the AEMC program is environmental sensors and biosensors. This program will concentrate in particular on developing new technologies for air and water monitoring and microbial detection, as well as refining and micro-miniaturizing currently available sensors. The program will also support the development of advanced implantable biotelemetry systems.

All AHST program sponsored investigations are peer-reviewed. The program relies upon external peer reviews to determine which research and technology to support. The program's research solicitations and peer review program are administered from Headquarters, and proposals submitted by NASA Field Center researchers are subjected to the same rigorous competitive standards as those of extramural researchers.

Contractor and Center Support

JSC is the lead center for the AHST. KSC manages life sciences payload integration/Spacehab, provides pre- and post-flight support, manages advanced life support facilities and demonstrations, and manages small payload investigations, especially those using plants. The Jet Propulsion Lab (JPL) is the lead for the AHST AEMC activities bringing their personnel and industry contacts to the development of sensors and monitoring capability.

MEASURES OF PERFORMANCE

	FY 1997		FY 1998		FY 1999
	plan	Actual	Plan	Revised	Plan
Number of Principal Investigators	52	42	39	40	71
Number of Co-lnvestigators supported	43	84	33	80	140
Number of Refereed Publications	41	38	38	40	70

ACCOMPLISHMENTS AND PLANS

During FY 1997, lead center program management responsibility for the AHST program was transferred from HQS to JSC.

ALS accomplishments include completion of a 60 day, closed chamber ISS Life support system test with four humans; completion of a 336 day closed-chamber wheat/potato shared atmosphere evaluation, and development and delivery of a solid waste processing subsystem for evaluation. SHF accomplishments included the study of human thresholds for electronically produced visual data at ARC, which have contributed to the data receipt and analysis of the Mars Pathfinder mission, and the beginnings of a rapid prototyping laboratory for advanced displays and controls in crewed vehicles. AEMC accomplishments included testing of an advanced Electronic Nose, developed by JPL, during the 60-day, closed-chamber test at JSC and development of detailed program requirements through consultation with industry and universities. The Electronic Nose is an advanced instrument for monitoring space craft atmosphere which combines an array of conducting polymers with neural network technology to sense a variety of chemical compounds. It replaces multiple sensors at reduced mass, volume and power requirements. The technology is expected to find broad applications for process and atmospheric monitoring on earth.

AHST will focus its ground-based activities during FY 1998 toward the development of technologies that will support specific needs during the ISS era and address the strategic thrusts of the HEDS. FY 1998 ALS milestones include completion of the 90-day, four person, closed-chamber life support systems test; and construction of the ALS lntegration Test Bed (formerly known as Bio-Plex).

SHF efforts in visual, auditory, and perceptual research will continue to investigate the thresholds of human interaction with onboard systems and crew accommodations evaluations and development for long duration missions will begin. AEMC milestones include Space Shuttle flight tests of the Electronic Nose. FY 1999 ALS milestones include: (a) completion of large-scale biomass production demonstration; (b) completion of CO_2 extraction system breadboard development; and (c) completion of one-year continuous crop production with recycling of waste streams. AEMC milestones include: Shuttle flight test of a miniature quadrapole mass spectrometer in late FY 1999.

BASIS OF FY 1999 FUNDING REQUIREMENT

BIOMEDICAL RESEARCH AND COUNTERMEASURES PROGRAM

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Biomedical Research and Countermeasures (BR&C) Program	44,100	40,600	50,000

PROGRAM GOALS

The BR&C Program develops understanding of the underlying mechanisms of the effects of space flight on humans. Its applied research activities also develop countermeasures to prevent undesirable effects of space flight on humans. The program includes several areas of research: space physiology, environmental health. radiation health, operational medical research, and behavior and performance. The overriding goal of these activities is to enable the human exploration and development of space by minimizing risks and optimizing crew safety and performance.

Specific goals of the program are as follows:

- Reduce risk to crew health from space radiation;
- Reduce risk of acute and chronic health problems, and of psychological and behavioral problems, that increase risk of crew mortality and morbidity, decrease crew productivity in flight, or prevent crew resumption of a full, healthy life on earth; and
- Transfer biomedical knowledge and technology gained through research on the ground and in space to the earth-based medical community.

STRATEGY FOR ACHIEVING GOALS

The BR&C program pursues its goals through both ground-based research and flight experiments. Flight research is typically preceded by ground-based research. All BR&C prograni sponsored investigations are peer-reviewed. The program relies upon external peer reviews to determine which research and technology to support. The program's research solicitations and peer review program are administered from Headquarters, and proposals submitted by NASA Field Center researchers are subjected to the same rigorous competitive standards as those of extramural researchers.

Ground-based research programs and projects are conducted at universities as well as NASA Specialized Centers of Research and Technology, NASA Centers, nonprofit and industrial organizations, and other federal agencies. In support of the science community, the program also finances unique gravitational simulation facilities such as centrifuges, parabolic aircraft. and other specialized support facilities and technologies such as chambers, bed rest studies, and data archiving.

Flight experiments pursue a balanced program taking advantage of flight opportunities which include human-assisted or human-subject flight opportunities aboard the Space Shuttle as well as research opportunities aboard unmanned vehicles. These experiniients use pressurized carriers (i.e. Spacelab and Spacehab) that fly in the Space Shuttle cargo bay as well as the Space Shuttle middeck for small payloads. As the nation approaches the era of the ISS, the BR&C program has taken advantage of longer-duration flight opportunities aboard the Mir space station. The NASA/Mir Research Program (NMRP) investigations have enabled the conduct of research, development of technologies, and helped mitigate the risks of long-duration space flight.

The BR&C program seeks to characterize and determine the mechanisms of physiological changes in weightlessness, including those that threaten to limit the duration of human space missions, It also develops methods that allow humans to live and work in microgravity, optimize crew safety, well-being, and performance, and minimize the deleterious effects of returning to earth's gravity after space flight. It attempts to specify, measure, and control spacecraft environments, and it develops standards and countermeasures, where necessary, to optimize crew health, safety, and productivity. The program develops monitoring techniques, procedures, and standards for extended missions. It also seeks to establish the scientific basis for protecting humans engaged in the development and exploration of space from radiation hazards.

Contractor and Center Support

The Lead Center for the BR&C program is JSC. ARC supports biomedical research investigations and plays the primary life sciences role in the development of biomedical flight experiments that require non-human subjects. KSC provides pre- and post-flight support for BR&C flight experiments.

MEASURES OF PERFORM :

	FY 1997		FY 1998		FY 1999
	plan	Actual	Plan	Revised	Plan
Number of Principal Investigators	199	160	206	192	163
Number of Co-Investigators supported	196	387	214	460	398
Number of Publications	295	276	306	290	249

ACCOMPLISHMENTS AND PLANS

During FY 1997, the selection and establishment of the Baylor College of Medicine consortium as the new National Space Biomedical Research Institute (NSBRI) marked a key initial milestone in Center-led activities which were transferred to JSC from HQS. The NSBRI will enable the BR&C program to tap into the vast wealth of knowledge and skills of the academic community in order to directly improve the capability of the Agency to meet the Agency's strategic goals for HEDS.

Other developments in the ground-based research program included a response to Congressional direction to fund technology enhancements in cardiac imaging, with focused support to the Cleveland Clinic in Ohio. In the flight experiment program, investigators continued work on two Spacelab missions, the Life and Microgravity Sciences (LMS) and Neurolab missions. The LMS investigators continued post-flight data analysis from the June 1996 mission and the Neurolab final selection of experiments were made in preparation for the April 1998 flight. Also during FY 1997, the program continued its participation in the NMRP with experiniients on long-duration crew members John Blaha, Jerry Linenger and Michael Foale.

During FY 1998, the BR&C program will undergo major restructuring and re-balancing of priorities in order to better respond to the goals of the HEDS Enterprise. This will begin with establishing a critical path road map against which all new research efforts will be judged. This also includes establishing new requirements for the Radiation Initiative focused at understanding the biological effects of space radiation and its mitigation.

The program will formulate a Countermeasures Research Plan responding to operational requirements set by the Space Medicine Function and evaluation focused on providing or developing the knowledge base for the safe practice of medicine in space. The working relationship with the NSBRI will continue to be fostered and enhanced to support these new directions.

In the flight program, the collaborative NASA/National Institutes of Health (NIH) Neurolab mission will be flown and the NMRP will continue its focus on describing the physiological changes of long-duration space flight, Preparations for the first Life Sciences mission to ISS will commence with the selection of the principal investigators and crew training in 1998. The last scheduled life sciences Spacelab flight is Neurolab, scheduled for the second quarter of FY 1998. The Neurolab niission will conduct basic research in sensory-motor coordination, vestibular function, spatial orientation, developmental biology, nervous system plasticity, autonomic nervous system control of the cardiovascular system, sleep and circadian rhythms, and human behavior. During FY 1998, the BR&C program will also fly one experiment as a small payload in the middeck area of the Space Shuttle.

During FY 1998 and FY 1999, the radiation health project will support ground-based experimental radiobiology studies using proton and high-energy heavy ion beams. FY 1998 and FY 1999 resources will continue to support studies attempting to understand the mechanisms responsible for radiation-caused carcinogenesis and the reliability of interspecies extrapolation of radiobiological effects. The radiation health program initiated a new collaborative venture with the National Cancer Institute (NCI) during FY 1996 that will continue during the budget period. This new NASA/NCI collaborative effort will provide up to $2.0 million per year of research funding through FY 2000. with each agency contributing equally. The collaborative project will attempt to define and understand the nature and extent of long-term genomic instability in mammalian cells caused by chronic low-dose radiation exposures of the kind likely to be encountered during extended space flight and in certain occupational settings. The radiation health project also includes a series of accelerator 'missions' at the Brookhaven National Laboratory, using the Alternating Gradient Synchrotron. These 'missions' will continue during FY 1998 and FY 1999. The investigations at Brookhaven will succeed a successful set of experiments completed during FY 1995, and will require approximately 150 hours of beam time each year to support the radiation health investigators funded jointly with the NCI. During FY 1999, NASA will support the modeling of the Galactic Cosmic Radiation (GCR) environment and Solar Particle Event (SPE) predictions as part of the radiation health project.

During FY 1998, a new collaborative effort will begin with the Office of Space Flight and the Office of Space Science to include radiation and soil/dust measuring devices on robotic missions to Mars. The first of these missions is planned for 2001, and includes a Mars orbiter and a Mars lander/rover, which are funded under the Office of Space Science's Mars Surveyor Program

(MSP). The MSP will provide a cost effective platform for gathering scientific data critical for achieving Human Exploration and Development of Space objectives. In FY 1998, a majority of the OLMSA effort will be in selecting and initiating the scientific research which will utilize the MSP platform. A majority of the Office of Space Science effort in FY 1998 will be focused on instrument design, with manufacturing efforts being conducted in FY 1999. Funding responsibility for the Principal Investigators associated with the radiation experiments and the associated data analysis will be provided from within the BR&C program. Funding responsibility for the experiment instruments and operations will be provided from within the MSP budget to maximize synergy in the orbiter and lander/rover design.

The BR&C program during FY 1999 will continue to balance and augment its efforts towards bringing to full support and definition the radiation program, countermeasures evaluation and validation project, and the ground-based research and technology development programs. The flight program elements consisting of Neurolab and the NMRP enter their final phases of data analysis, evaluation and reporting. The flight program also expects to fly two small payloads investigations. Preparations continue for the first focused Life Sciences Research on the ISS (UF-1 and UF-2) and the advanced planning for the following ISS research opportunities.

BASIS OF FY 1999 FUNDING REQUIREMENT

GRAVITATIONAL BIOLOGY AND ECOLOGY PROGRAM

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Gravitational Biology and Ecology (GB&E) Program	33,600	30,000	37,100

PROGRAM GOALS

The GB&E focuses on research designed to improve our understanding of the role of gravity in biological processes from the cell to global ecosystems. The emphasis in this program is on advancing fundamental knowledge in the biological sciences, but the research supported often also contributes to the other goals of the HEDS Enterprise. The program solicits research in molecular, cellular, developmental, organismal, population and comparative biology that seeks an understanding of basic mechanisms underlying the effects of gravity on these systems. NASA continues to value ground-based research that leads lo flight experiments that can confirm or refute the fidelity of ground-based models and hypotheses.

Specific GB&E prograni goals are:

- Determine and elucidate the effects of gravity on, and the gravity response of cellular structures, the genome, cells, physiological systems, organisms and their development, ecosystems, and biological evolution:
- Apply knowledge to support human space flight via countermeasures and bioregenerative life support systems, and further exploration of space via terraforming technologies ; and
- Transfer biological knowledge and technology gained through research on the ground and in space to the earth-based medical and scientific communities

STRATEGY FOR ACHIEVING GOALS

The GB&E program seeks to improve understanding of the role of gravity in biological processes by using a variety of gravitational environments as research tools or by determining the combined effects of gravity and other environmental factors on biological systems. The program emphasizes research in cell and molecular biology, evolutionary and developmental biology, and organismal and comparative biology. Its research includes plants, animals, or other organisms as subjects, as well as cell or tissue cultures. The disciplines supported by this program are: Cellular and Molecular Biology, Developmental Biology. Plant and Comparative Biology, Global Monitoring and Disease Prediction, Gravitational Ecology (planned), and Evolutionary Biology (planned).

The GB&E program sponsors multidisciplinary technology development activities that enhance the capability, reliability, and quality of flight hardware. The program solves technical problems that currently limit science return from existing flight equipment. It enables new types of scientific investigations in space; promotes transfer of technology to industry: and establishes partnerships with industry, universities, and other agencies.

The GB&E program provides a balanced and robust series of flight opportunities which include human-assisted flight Opportunities aboard the Space Shuttle as well as research opportunities aboard unmanned vehicles. The program uses Spacelabs and Spacehabs that fly in the Space Shuttle cargo bay as well as the Space Shuttle middeck for small payloads. As the nation approaches the era of the ISS, the program is taking advantage of longer-duration flight opportunities aboard the Mir space station. These investigations will enable the program to conduct research, develop technologies, and help mitigate the risks of long-duration space flight. In the ISS era, crews will remain on orbit for as long as 180 days at a time: the GB&E program will provide enabling technologies to take maximum advantage of this long-duration opportunity.

All GB&E program sponsored investigations are peer-reviewed. The program relies upon external peer reviews to determine which research and technology to support. The program's research solicitations and peer review program are administered from Headquarters, and proposals submitted by NASA Field Center researchers are subjected to the same rigorous competitive standards as those of extramural researchers.

The GB&E program is the lead center for the Life Sciences Outreach Program. The Outreach Program pursues its activities with local autonomy, manages agency-wide programs, and bears responsibility for strategic and program planning, prioritization and implementation of projects, as well as reporting. Audiences reached include professional and technical societies, the general public, educators and students K-12, college/university faculty and students. Approaches include educator workshops, interactive Internet resources, web sites, classroom materials (multimedia and hard copy), brochures, live and real-time participatory interactions with Life Sciences missions and facilities, graduate study fellowships. community and university led distance learning, and videos. As appropriate, activities are highly leveraged with NASA's Education and Equal Opportunity codes. Partnerships include science and technology museums, PBS affiliates, academic institutions, for-profit, and non-profit organizations: implementation is through contracts, subcontracts, grants and cooperative agreements, MOUs and unreimbursed Space Act Agreements, and civil service designees.

Center Support

ARC is the lead Center for the program. GB&E also draws upon other Centers on occasion to administer tasks or for other unique expertise. The responsibility for grant peer review and selection for funding remains at Headquarters. As a result, all proposals selected for funding, both those submitted by extramural investigators as well as those from intramural researchers at NASA Centers, must withstand a Headquarters-managed, conipetitive selection process. Those investigations that receive grant awards are administered by ARC.

Collaborative Activities

A key collaborative venture between NASA and National Institutes of Health (NIH) is the use of remote sensing technologies for the prediction and control of global vector-borne human disease such as malaria. This activity is jointly administered with the National Institute of Allergy and Infections Diseases.

Life Sciences also participates with other federal agencies such as the Center for Disease Control and Prevention and a variety of other national and international organizations whose research interests intersect those of the GB&E program. These organizations include the National Science Foundation, and the American Society for Gravitational and Space Biology (ASGSB).

MEASURES OF PERFORMANCE

Current performance measures for GB&E include number of principal investigators supported, number of research proposals received and number of major journal publications.

	FY 1997		FY 1998		FY 1999
	Plan	Actual	plan	Revised	plan
Number of Principal Investigators	**113**	91	94	88	92
Number of Co-Investigators supported	52	102	43	90	100
Number of Publications	189	177	180	170	190

ACCOMPLISHMENTS AND PLANS

The NASA/Mir Science program is part of ISS Phase 1 which is serving as a prologue to ISS assembly in Phases 2 and **3.** Fundamental Biology is one of seven disciplines conducting research during the Phase 1 program. The current Fundamental Biology research program includes: avian developmental biology, plant biology, circadian rhythm research and radiation monitoring. While a period of months will be required for the results of FY 97 Mir experiments to be analyzed and published, the following are some representative highlights:

- Work on Mir has demonstrated the ability to complete a 145-day wheat growth life cycle from seed germination through flowering and the development of mature seed heads. Unexpected seed infertility results are still under study.
- Mir has also allowed scientists to conduct a successful seed to seed experiment using brassica (a relative of broccoli). Seeds developed in space have germinated and produced seeds. A third generation was initiated in September, 1997. All the specimens were returned to the ground by Astronaut Michael Foale and are under analysis by the principal investigator.
- Mir research has demonstrated that early stage avian embryos can develop in microgravity (in contrast to earlier shuttle experiments).
- Mir research has resulted in a significant expansion of the United States database on radiation effects at the 51.6degree inclination orbit.

The first cooperative scientific payload with the National Space Agency of Ukraine, the Collaborative Ukrainian Experiment (CUE), flew in November, 1997. The CUE consists of eleven plant science experiments. These experiments were developed in joint cooperation between five U. S. scientists in four universities and one corporation, and 16 Ukrainian scientists at six institutes of the Ukrainian Academy of Sciences. Colonel Leonid Kadenyuk, the primary payload specialist and the first Ukrainian to fly on the U.S. shuttle, perfonned the procedures for the experiments. These experiments will provide scientists with a deeper understanding of:

- How plants perceive and respond to gravity;
- The role of gravity in development and reproduction;
- The role of gravity in photosynthesis and metabolism; and
- How gravity and other environmental factors interact.

A special component of the CUE is its educational program, Teachers and Students Investigating Plants in Space (CUE-TSIPS). CUE-TSIPS offered a real-time investigative opportunity for United States and Ukrainian teachers and students. During the orbiter Columbia's 16-day flight, students in both countries duplicated a flight plant biology experiment in their classrooms under the influence of earth's gravity. Comparison of data and results will continue after the flight.

During FY 1997, the Biocomputation Center was established by NASA in collaboration with Stanford University. The Biocomputation Center is dedicated to computer-based three-dimensional (3-D) visualization of cells, tissues and organs, to mathematically-based modeling, and to 3-D siniulations of the functioning of living systems from the subcellular and molecular to the organismal level. The emphasis is on teams of broadly based, interdisciplinary investigators and on a union between computational. theoretical and experimental research.

FY 1998 will be highlighted by the flight of Neurolab. Neurolab is a spacelab mission which focuses on the effects of microgravity on the brain and behavior. The combined creativity and skill of its international team of investigators, engineers, scientists, and operations personnel has been brought to bear on this, the most ambitious life sciences mission to date. Specifically, this mission will:

- Use microgravity to study the development and adaptation of gravity sensing systems by using a variety of biological specimen;
- The first to utilize anesthesia to perform recovery surgery on-orbit;
- Assess the adaptive capability of mammalian brain cells synapses and neurotransmitters to space flight; and
- The first to utilize state-of-the-art electrophysiological recording methods to study mammalian brain cell activity patterns in space.

During FY 1998 and FY 1999, Investigations, including renewals and new awards, will concentrate on the areas of cell biology, developmental biology, and comparative biology. Cell biology investigations will examine how gravitational information is transduced, how cells respond to acute and long-term variations in gravity, and how gravity affects the composition, size, shape, and function of cells. Developmental biology investigations will study the influence of gravity and microgravity on animal growth, development, reproduction, genetic integrity, life span, senescence, and subsequent generations of animals. Comparative biology research will be conducted to understand how animals and plants perceive, transduce, and respond to gravitational force. The investigations will elucidate the role of hypergravity and microgravity in developmental and reproductive processes and will seek to understand the role of hypergravity and microgravity in such areas as the metabolism and transport processes in animals and plants. During FY 1999, NASA will continue funding the Biocomputation Center and continue exploring with Stanford University the formation of an extramural center for that activity. The program will continue to encourage extramural investigators to take advantage of NASA-unique facilities to support research objectives. The program will use FY 1998 and FY 1999 budgetary resources to increase extramural access to the Biocomputation Center, the Vestibular Research Facility and other radial acceleration facilities at ARC.

BASIS OF FY 1999 FUNDING REQUIREMENT

MICROGRAVITY RESEARCH PROGRAM

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Microgravity Research (MR) Program	105,300	100,400	106,700

PROGRAM GOALS

The MR program seeks to understand basic physical phenomena and processes, quantify effects and overcome limitations imposed by gravity on the observation and evaluation of selected phenomena and processes: develop technologies related to the requirements of the research; and expand, centralize and disseminate the research data base as widely as possible to the U.S. research and technology community. The primary goal of the MR program is to advance fundamental scientific knowledge in physical, chemical, and biological processes and to enhance the quality of life on earth by conducting scientific experiments in the low-gravity environment of space, and to mature the research of a large number of laboratory scientists into coherent groups of flight experiments.

STRATEGY FOR ACHIEVING GOALS

The MR program uses ground-based research to find and refine concepts for space experiments, and to create a framework of knowledge and expertise in which the full scientific value of space experiments can be realized. The program utilizes the nation's academic and industrial resources, joining prominent researchers with NASA expertise in multidisciplinary microgravity experimentation. The program employs an open, competitive, peer-reviewed research solicitation process including the regular release of NASA Research Announcements (NRAs) in specific disciplines and reviews of proposals by independent panels of experts.

Approximately 80% of the research and analysis budget funds are awarded for research grants and contracts through competitive peer review, with over 90% of this funding going to external investigators across the U.S.. The remaining 20% is used at NASA Field Centers to provide supporting infrastructure. Since the inception of the research program in 1989, 16 NRAs covering five disciplines have been released, and over 2,500 proposals have been received. Over 300 Principal Investigators are now in the peer-reviewed Research and Analysis ground-based program.

Over the last decade, NASA has established an active scientific program in microgravity research utilizing the Space Shuttle as a research tool. As the program moves toward the next century, the focus will shift from use of the Space Shuttle toward use of the ISS. The strategy for accomplishing the transition from the Shuttle to the ISS is to use the NASA/Mir program to mitigate risk in scientific, technological, logistical, and operational planning. Today, the MR program is utilizing both the Space Shuttle and the

NASA/Mir to achieve its objective of providing flight experiment opportunities for investigators who can benefit from conducting experiments in the low-gravity environment of earth orbit. The flight program provides scientific apparatus (e.g., flight hardware) for experiments for a wide range of flight opportunities in the Space Shuttle middeck, Space Shuttle cargo-bay, Spacelab, Spacehab, Hitchhiker and Get Away Special (GAS) carriers. Scientific apparatus for the NASA/Mir and the ISS are funded by the Space Station budget. Experiment apparatus ranges from small hand-held single experiments to multi-rack, facility-class hardware which can accommodate multiple investigators.

The five science disciplines which comprise the MR program are biotechnology, combustion science, fluid physics, fundamental physics, and materials science.

Biotechnology

The biotechnology discipline focuses on protein crystal growth, cell science, and fundamentals of biotechnology as areas which offer promising opportunities for significant advancements through low-gravity experiments. Experiments in space have demonstrated that gravity influences protein crystal growth and that reduced gravity can result in improved crystal characteristics. Improved data from protein crystals will allow scientists to better understand protein structures, a critical element of structural biology and rational drug development. Cell science technology explores the cellular response to low stress environments in a technology central to contemporary biomedical research. Growing normal and cancerous tissues is a technology with enormous medical benefits and applications. Fundamentals of biotechnology is an area of exploratory research in new directions such as separation and purification of biological materials.

Combustion Science

Combustion is responsible for producing 85% of the world's energy as well as a significant fraction of atmospheric pollution. Combustion reactions release heat which under gravity's influence causes a convective flow as the heated gas rises. By reducing this flow in a low gravity environment, important problems such as soot formation in flames, the spreading of fires, the burning of hydrocarbons and limits of flammability can be studied under conditions which can be analytically modeled and which provide insight to flames in practical combustors. The applications of this research to fire safety and control are becoming significant.

Fluid Physics

The fluid physics discipline studies the properties and motions of liquids and gases, providing a conceptual framework in which to understand the role of gravity in physical and chemical processes. The program also provides a foundation for advances in technologies required for exploration and development of space, such as regenerative life support systems, utilization of local resources, propulsion systems, power generation, cryogenic and fluid management. Scientists study how fluids flow under different conditions, how energy affects fluid flows, and many other important scientific and practical issues. Investigators seek the ability to make accurate predictions of how heat and mass are transported in mixtures of fluids and vapor, with profound implications for production and control processes on earth and in future space engineering applications.

Fundamental Physics

The fundamental physics discipline includes the study of critical phenomena, low-temperature physics, laser cooled atomic physics, gravitation and relativity, and other phenomena for which the space environment can make possible measurement of physical constants with levels of accuracy that challenge the contemporary theories in physics. Reduction and control of the forces due to gravity allow investigations to probe into the depths of physical variables lo levels that allow the verification of universal theories which can then be used in a great many fields of physics with much greater confidence.

Materials Science

The materials science discipline examines the relationship between processing, structure, and properties, and strives to acquire the basic knowledge required to develop new generations of high performance materials in areas including electronic and photonic materials, glasses and ceramics, metals and alloys, and polymers and nonlinear optical materials. The properties of a material are largely determined by the structure of the material, and are greally influenced by the process used in forming the material. Gravity-driven phenomena can play a huge role in this triangle of properties/processing/structure. Utilization of the low gravity environment to give insight into materials and materials processing may result in improvements to production methods and materials on earth.

Center and Contractor Support

MSFC is the MR program lead Center and also responsible for execution of the materials science and biotechnology portions of the program, and manages the Glovebox Program. JSC contributes to the biotechnology research program by administering research in cell science. The Lewis Research Center (LeRC) implements combustion science and fluid physics. JPL implemenls the fundamental physics portion of the program. Contractors are utilized for science support at the Centers and are responsible for understanding and nionitoring certain investigators' science. They also assist the external scientists in the utilization of unique facilities at the centers required to carry out some of the low gravity experimentation.

The National Center for Microgravity Research on Fluids and Combustion was established in 1997 through a joint cooperative agreement between the Universities Space Research Association, Case Western Reserve University and LeRC. The mission of the Center is to lead a national effort to increase both the number and quality of researchers and to accomplish integrated, critical path research in microgravily fluids and combustion sciences. New research centers in the areas of Materials Science and Biotechnology are planned lo be established in FY 1999.

MEASURES OF PERFORMANCE

	FY 1997		FY 1998		FY 1999
	plan	Actual	Plan	Revised	Plan

Number of Principal Investigators	330	342	340	349	344
Number of Co-Investigators supported	330	374	340	395	395
Number of Publications	1320	1446	1360	1370	1420

ACCOMPLISHMENTS AND PLANS

FY 1997 Missions
Microgravity Science Laboratory (MSL-1)
Planned Launch: 2nd Qtr FY 1997
Actual Launch : 3rd Qtr FY 1997
Reflight: 4th Qtr FY 1997

The MSL-1 flight and the unprecedented MSL-1 re-flight, three months later carried major NASA-developed instruments for research in combustion science and fluid physics, Combustion Module-1 (CM-1), the Droplet Combustion Experiment (DCE) and the Physics of Hard Spheres Experiment (PHASE), These investigations explored phenomena central to pollution control, engine efficiency, fire safety, and phase transformation. Using both German and Japanese-developed hardware and both U.S. and international investigators, niaterials science research continued investigations which were begun on International Microgravity Laboratory (IML-2).This was also the first flight of the Quasi-Steady Acceleration Measurement system developed by Germany. The upgraded Microgravity Measurement Assembly (MMA), developed by the European Space Agency, was also flown for the second time. These instrunients complemented the Space Acceleration Measurement System and Orbital Acceleration Research Experiment (OARE) on this flight.

United States Microgravity Payload (USMP-4)
Planned Launch: 1st Qtr FY 1998
Actual Launch: 1st Qtr FY 1998

The USMP-4 mission focused on experiments in fundamental physics and microgravity materials science. New apparatus for the Confined Helium Experiment (CHeX) investigation, plus major upgrades of other apparatus were flown. Both European and U.S. investigations were conducted.

Accomplishments

NASA continued investigations selected from the 1994 and 1996 fluid physics, materials science, and combustion science NRAs. The investigations currently supported will define the first phase of ISS microgravity research. Further growth in these disciplines is planned toward the end of the decade, when it is anticipated that preparation for ISS research will grow in scope and intensity.

In FY 1997, a strategic road map for the MR program, with strategies to accomplish program objectives, was prepared. This road map is analogous to those developed for NASA and the HEDS Enterprise. In addition, strategic road maps for each of the MR sub-disciplines (biotechnology, combustion science, fluid physics, fundamental physics, and materials science) were prepared. The development of these road maps ensures that the MR program is fully aligned with the HEDS and NASA strategic goals.

The major FY 1997 efforts in the Microgravity Flight Experiments Program were focused on the MSL-1 initial and reflight missions, USMP-4 mission and suborbital rockets.

Biotechnology

NASA awarded grants for 36 new investigations selected from the third Microgravity Biotechnology NRA. The fourth Biotechnology NRA, released in December 1997, **will** provide another definitive opportunity for experiments in protein crystal growth, tissue culturing, and fundamental studies of other areas of biotechnology. Several of these research tasks are cooperative efforts with the NIH.

Cooperative activities between the NASA and the NIH National Eye Institute on the use of a laser light scattering diagnostic instrument continued. The National Eye Institute, will use the probe for early detection and diagnosis of eye diseases such as cataracts, diabetic retinopathy, and the inflammatory diseases of the anterior chamber of the eye. NASA is also collaborating with the National Eye Institute using protein crystal growth technology to determine the structures of important proteins related to the signal pathway for sight. This is a joint program between NASA, NIH, and Eli Lilly.

NASA and the Juvenile Diabetes Foundation have begun a cooperative program. The Foundation for Transplant Research was selected to research a novel treatment for diabetes. The research involves application of the NASA biotechnology bioreactor to stimulate growth and aggregation of insulin producing adult hunian islet cells in a simulated microgravity environment. The resulting cells will then be encapsulated and transplanted into patients to prevent the onset of Type I diabetes.

Research into new technologies for x-ray diagnostics of protein crystals has resulted in the development of a new brilliant x-ray system. This new system is capable of producing a focused x-ray beam that is more than 50 times brighter than conventional beams at a fraction of the power consumption. This new technology is so promising that activities are underway to expand the development to make the system available to ground-based laboratories throughout the research community. This new proposal is a joint venture including NASA, industry, academia, and the NIH.

During FY 1997, the Biotechnology discipline supported 13 experiment instrument flights in protein crystal growth and cell science. The biotechnology crystal growth program flew over 3,200 samples of more than 50 biological materials such as proteins, nucleic acids, viruses, and other large molecules. Crystals from these experiments resulted in improved resolution of the molecular structure of 16 such materials. These improvements will be used to begin the process of structure based drug development and will affect other key industrial processes. Examples of the 16 improved structures are:

- Antithronibin: a protein involved in the coagulation of blood:
- 5srRNA: a key nucleic acid involved in protein synthesis:
- Canavalin: a protein serving as a major source of energy storage in plants: and
- Antibody to Respiratory Syncytial Virus (disease responsible for over 4000 infant deaths per year).

Numerous samples were also flown as part of ongoing experiments designed to improve our understanding of how to grow quality crystals of biological materials both on earth and in space.

A number of Cell Science milestones were accomplished on orbit and in post flight testing. Analysis of the bovine cartilage grown on-orbit revealed that the tissues remained viable during a 78 day niission. The cellular constructs of the cartilage were observed to have fused during flight. On-orbit culturing of colon carcinoma cells was also successfully repeated on STS 85. This reflight appears to confirni that the cells grown in space were more differentiated (specialized) and hence more like those found in the human body than cells cultured here on earth.

Combustion Science

NASA released the 1997 Microgravity Combustion NRA in October of FY 1998. **In** preparation for the NRA release, the Fourth International Microgravity Combustion Workshop was held in the third quarter of FY 1997. This NRA will specifically solicit research that supports the HEDS exploration activities, advances economically significant technologies, and supports technology infusion onto the private sector. In addition it will solicit proposals in the historical research areas of gaseous flames; droplet, particle, spray, and dust flames: ignition and flame spread over liquid and solid surfaces: smoldering combustion and combustion synthesis.

More than 200 combustion experiments runs (fires) were conducted on MSL-1, resulting in the discovery of a new niechanisni of flame extinction caused by radiation of heat from soot. The MSL-1 crew were able to sustain the weakest flames ever burned either in space or on earth and were able to study the longest burning flames ever ignited in space.

The ground-based program studying the flame spread and ignition limits in a variety of diluents has determined that thin paper fuels are flammable at slightly lower oxygen concentrations with CO, as a diluent than they are in other diluents (nitrogen, heliuni etc.) This is attributed to the fact that CO, is a more effective absorber of flame radiation than the other gases. This result is significant since CO, is the extinguishing agent on the ISS fire extinguishers. Further study of CO, as an extinguishing agent is planned.

The Droplet Combustion Experiment (DCE), Study of Flame Balls at Low Lewis Number (SOFBALL), Laminar Soot Processes Experiment (LSP) and Fiber supported Droplet (FSDC) experiments all flew on the MSL-1R mission. All of the combustion experiments achieved extremely high levels of success. To improve our understanding of spray combustion which is used in many practical systems, DCE and FSDC provided the first extensive data set of one-dimensional droplet combustion data. SOFBALL examined the limits of the simplest combustion systems (premixed gases) and in so doing, produced the weakest flames ever produced and provided the first ever verification of a novel theory of flame stability. Soot is ubiquitous in practical combustion and is the leading cause of death from unwanted fires and air pollution. The LSP experiment studied soot growth and oxidation in microgravity, providing the first opportunity to develop practical predictive tools for soot formation in flames on earth.

The USMP-4 mission in November 1997 carried two more combustion experiments into space. A glovebox experiment, Enclosed Laminar Flames (ELF), studied coflowing gas jet diffusion flames, providing new insight into flame stability and attachnient without the interference of buoyant flows, The Turbulent Gas-Jet Diffusion Flames (TGDF) experiment, a Get Away Special Canister (GAS-CAN) payload studied the transition to turbulence in disturbed gas-jet diffusion flames.

Fluid Physics

In late 1997, NASA awarded 33 investigations in the discipline of microgravity fluid physics. The selections from the 1996 Fluid Physics NRA represented a 50% increase in the number of ground-based research tasks supported in this program and has introduced new areas of research into the discipline, specifically in the areas of complex fluids, granular flows, bio-fluids and transport processes underlying in situ resource utilization (ISRU).

The Physics of Hard Spheres Experiment (PHaSE).carried aboard the July 1997 MSL-1R mission, examined order-disorder transitions in colloidal suspensions. This laser light scattering instrument, using cutting edge technology, produced startling and unexpected findings. The data revealed that colloidal particles diffusion is more rapid in the absence of gravity than in its presence. The PHaSE instrument itself was featured on the cover of the October 1997 issue of Applied Optics, the prestigious journal of the Optical Society of America. PHaSE was the first Expedite-the-Processing-of-Experiments-to-Space-Station (EXPRESS) rack payload flown to validate the use of the EXPRESS rack planned for the ISS.

Fundamental Physics

Six new flight definition experiments were selected from the **83** proposals to the 1996 Fundamental Science Physics NRA, increasing the number of flight experiments being developed from **4** to 10. Two investigations were chosen in each of the three subdisciplines: Low Temperature Condensed Matter, Laser Cooled Atomic Physics, and Gravitation and Relativity. The latter two areas are the first flight definition experiments supported in these new subdisciplines, demonstrating the broadening of the science areas being investigated in this discipline.

In response to the ***83*** proposals received for the 1996 NRA for Fundamental Physics, NASA awarded 20 new ground-based investigations, essentially doubling the size of this research program. The addition of eight new investigations of Laser-Cooled Atomic Physics (LCAP) increases this subdiscipline three-fold. One of the new LCAP investigators, William Phillips of the National Institute of Standards & Technology (NIST), shared the 1997 Nobel Prize in physics for his research in this area, and another new investigator in the low temperature area, David Lee of Cornell, was a laureate in 1996. New topics being investigated include mass interferometry, atom lasers, and precision gyroscopes based on such phenomena, measurements made possible by the very cold temperatures (within 10^{-9} degree of absolute zero) of the atomic sample and the resulting coherence of the wave function representing these supercold atoms. Also, four new selections were made in the gravitation and relativity subdiscipline, further broadening the range of basic topics being studied. The growing community of investigators and the maturity of their investigations has led to increases in the number of publications produced. The next NRA for this discipline will be released in the year 1999. The growth of this discipline supports the formation of a Discipline Working Group (DWG) to help guide its development. Professor Guenter Ahlers of the University of California, Santa Barbara is acting as the chairman of the DWG. The membership includes experts in each of the subdisciplines. Nobel Laureate Doug Osheroff of Stanford University has agreed to serve on the DWG.

The Critical Viscosity of Xenon (CVX) experiment was conducted on STS-85 in August 1997. This is a fundamental physics experiment to determine the critical exponent for xenon more accurately than is possible under normal gravity. The CVX data will be used to quantitatively test the niathematical form for the crossover theory of critical viscosity and provide complementary results with the Zeno experiment to test the mode coupling theory of critical phenomena. Measurements, 30 times closer to the critical point than possible on earth, were made to confirm the weak divergence theory of viscosity near the critical point. The weak divergence of the viscosity was clearly seen in the microgravity environment, and it was approximately twice as large as the best measurements on earth. The divergence is strongly masked in earth's gravity due to stratification of the fluid density. The confined Helium Experiment (CHeX) successfully completed flight on USMP-4/STS 87. The data show that the thermometers have the same high resolution they displayed on earth (10^{10} degree), and the facility is providing an extended lifetime that will enable enhanced science return from the increase of data gathering time. Clear evidence for the confinement effects have been observed in the data.

Materials Science

NASA selected 42 microgravity materials science research and analysis investigations from proposals submitted for the 1996 NRA release. The awards ranged from basic and applied scientific research to the development of advanced data acquisition and thermophysical condition-generation technology. Investigations broadened the established field of microgravity niaterials science research and analysis, with emphasis on studies of fundamental scientific phenomena and specific classes of materials such as polymers and glasses and ceramics.

Seven materials science experiments were conducted on the First Microgravity Science Laboratory (MSL-1R) mission in July of 1997: "Coarsening in Solid-Liquid Mixtures" (CSLM), "Liquid Phase Sintering-2" (LPS-2), "Diffusion Processes in Molten Semiconductors" (DPIMS), "Experiments on Nucleation in Different Flow Regimes", "Alloy Undercooling Experiments", "AC Calorimetry and Therniophysical Properties of Bulk Glass-Forming Metallic Liquids", and "Measurement of Surface Tension and Viscosity of Undercooled Liquid Melts". Primarily directed at exploring fundamental issues in materials science, these experiments investigated the processes by which microstructures fonn during materials processing. For example, MSL-1R yielded the first measurements of specific heat and thermal expansion of glass-forming metallic alloys and produced the highest temperature and largest undercooling ever achieved in space. This work has direct application to the design of steel strip casting facilities on earth and helps scientists understand how welding processes may be conducted in space.

Six materials science experiments were conducted as part of the Fourth United States Microgravity Payload (USMP-4) on the space shuttle Columbia in November of 1997. The mission:

- provided data which will help to discriminate between two competing theories of solidification in metals;
- provided critical information on the solidification of electronic materials that will not only help to produce better quality materials on earth, but will also help define future efforts of crystal growth in space and lead the way to an even deeper understanding of the most basic aspects of crystal growth;
- produced benchmark samples of Mercury-Cadmium-Telluride, an important material for research in electronics;
- provided data on the interaction between solid liquid interfaces and particles that will be used to develop a theoretical basis for processing coniposite materials on earth; and
- explored the production of exotic "immiscible alloys" in microgravity.

During FY 1998, a new collaborative effort will begin with the Office of Space Flight and the Office of Space Science to include radiation and soil/dust measuring devices on robotic missions to Mars, The first of these missions is planned for 2001, and includes a Mars orbiter and a Mars lander/rover, which are part of the Office of Space Science's Mars Surveyor Program (MSP). The MSP will provide a cost effective platform for gathering scientific data critical for achieving Human Exploration and Development of Space. In FY 1998, a majority of the OLMSA effort will be in selecting and initiating the scientific research which will utilize the MSP platform. A majority of the Office of Space Science effort in FY 1998 will be focused on instrument design, with manufacturing efforts being conducted in FY 1999. Funding responsibility for the Principal Investigators associated with the soil/dust experiments and the associated data analysis will be provided from within the MR program. Funding responsibility for the experiment instruments and operations will be provided from within the MSP budget to maximize synergy in the orbiter and lander/rover design.

NRAs for Fluid Physics, and Materials Science will be released in FY 1998, NASA plans to roughly plateau the number of Microgravity ground-based Principal Investigators in FY 1998, and continue preparations for research utilization of the ISS. NRAs for Biotechnology, Combustion, and Fluid Physics will be released in FY 1999. The primary emphasis in FY 1999 will be on final preparation for early utilization of the ISS. The flight sciences activities will focus on the preparation for flight of the first ISS payloads which include the Physics of Colloids in Space (PCS) experiment and the second generation of the Space Acceleration Measurement System (SAMS II). Close coordination with our international partners will continue on development and implementation of an international strategic microgravity research program. Research Announcements in the microgravity disciplines will continue to include research in basic science and technology which may have applications to advanced space missions. Scientific investigations will continue to be selected for development of technology which enhances the capability and quality of experimental hardware or reduces technology-based limitations. On The STS-95 research mission scheduled to launch in FY 1999, the Microgravity Research Division plans to conduct three fluids investigations in the rniddeck glovebox as well as Protein Crystallization experiments. The fluids experiments will study colloidal fluids and internal flows in drops. MR will add emphasis to the work in support of the MARS 2001 robotic mission. Radiation shielding technology and the use of extraterrestrial resources ground based research will be pursued. The first flight of the Extensional Rheology Experiment (ERE) will be conducted on a sounding rocket in late FY 1999.

BASIS OF FY 1999 FUNDING REQUIREMENT

SPACE PRODUCT DEVELOPMENT

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Space Product Development (SPD) Program	13,000	12,900	14,400

PROGRAM GOALS

The goal of the SPD program is to facilitate the use of space for commercial products and services and to use the unique attributes of space to conduct industry driven research in which materials or knowledge developed in space can be used on earth for the development or improvement of a commercial product or service. Commercial space research has the potential to create new or improved products, create jobs, give U.S. industry competitive advantages and improve the quality of life on earth.

STRATEGY FOR ACHIEVING GOALS

The budget discussed in this section supports the operation of the NASA Commercial Space Centers (CSC), conimercial flight research hardware for Shuttle and parabolic aircraft flights, and a limited number of NASA projects in support of commercial objectives.

The SPD program is managed for NASA by the Microgravity Research Program Office at the MSFC. The SPD program is primarily implemented through CSCs. Each CSC is a non-profit entity headed by a Director which leads a consortia of commercial, academic and/or government entities. The CSCs pursue product-oriented research in disciplines such as biotechnology, biomedicine, agriculture and materials processing. NASA's role in this partnership is to provide leadership and direction for the integrated program and to provide the flight opportunities that are essential to the success of these efforts. The SPD program includes the following CSCs:

Center for Bioserve Space Technologies (SBST)	University of Colorado at Boulder
Center for Macromolecular Crystallography (CMC)	University of Alabama at Birmingham
Consortium for Materials Development in Space (CMDS)	University of Alabama at Huntsville
Space Vacuum Epitaxy Center (SVEC)	University of Houston, Texas
Wisconsin Center for Space Automation and Robotics (WCSAR)	University of Wisconsin at Madison
Center for Commercial Applications for Combustion in Space (CCACS)	Colorado School of Mines, Golden, CO
Microgravity Automation Technology Center	Environmental Research Institute of Michigan, Ann Arbor, MI

Solidification Design CASTNET Center (SDCC)	Auburn University, Auburn, AL
Center for Advanced Microgravity Materials Processing (CAMMP)	Northeastern University, Boston, MA
Marshall Space Flight Center (MSFC)	Huntsville, AL
Space Center for Medical Informatics and Applications	Yale University, New Haven, Connecticut

The CSCs have a unique and integral role in assisting private industry in conducting space research. They demonstrate to industry the values of space research and they provide expertise essential to the conduct of successful research in space. CSCs furnish infrastructure that provides an inexpensive and effective way to develop and conduct research in space. CSCs also initiate industry involvement first by identifying and investigating areas of potential commercial promise, and second by marketing these potential research opportunities to private companies. As participants, the commercial affiliates must support the research effort with money, technical expertise, saniple materials, personnel, ground facilities and hardware.

NASA's success at encouraging the commercial use of space is demonstrated by the many commercial partners, potential products nearing marketability and the increasing industry contributions to microgravity research. Currently, the commercial payload developers have a combined total of 220 affiliates. To date the CSCs commercial partners have invested over $430 million in commercial space research. Space Shuttle missions, the NASA/Mir program and sounding rocket flights have supported over 200 commercial research activities.

MEASURES OF PERFORMANCE

The measures of performance for the SPD program capture the number of university and industry affiliates that are working with NASA in the commercialization of space and the amount of funding leveraged from non-NASA sources by the Commercial Developnient Centers.

	FY 1997		FY 1998		FY 1999
Flight Hardware Utilized	Plan	Actual	plan	Revised	plan
Industry Affiliates	50	131	30	136	198
University Affiliates	50	58	20	58	50
Payloads Flown	5	10	2	4	14
Non-NASA $M Leveraged	$40.0M	$47.7M	$30.0M	$49.3M	$53.6M

ACCOMPLISHMENTS AND PLANS

Major Payloads for FY 1997-99

FY 1997	Payload	Plan	Actual
STS-80/Columbia	Wake Shield Facility-3/Commercial Microgravity ITA Experiment-4 (commercial experiment)	November 1996	November 1996
STS-83/Columbia	Astroculture/Plant Generic Bioprocessing Apparatus/Commercial Protein Crystal Growth	March 1997	April 1997
STS-94/Columbia	Astroculture/Plant Generic Bioprocessing Apparatus	July 1997	July 1997
STS-86/Atlantis	Liquid Phase Sintering/Commercial Generic Bioprocessing Apparatus/Commercial Protein Crystal Growth	September 1997	September 1997

FY 1998	Payload	Plan/Revised
STS-89/Endeavour	X-ray Detector Test/Astroculture	January 1998
STS-93/Columbia	Aerogel	August 1998

FY 1999	Payload	Plan
STS-95/Discovery	Commercial Protein Crystal Growth, Commercial Biomedical ITA Experiment, Commercial Generic Bioprocessing Apparatus, Astroculture, Zeolite Crystal Growth, Biodyn/A & B, Advanced Separations, Aerogel, Microencapsulation Electrostatic Processing System, Containerless Melt Freeze, Astro-Plant Generic Bioprocessing Apparatus	October 1998

The CMC, in collaboration with one of its corporate partners, has developed a potential new treatment for influenza. Using data from space grown crystals, researchers from the CMC identified the structure of the protein crucial to the flu's ability to infect the body. This protein is know as neuraminidase. Information from space grown crystals has enabled the design of neuraminidase inhibitors which will reduce the spread of the virus throughout the body. These inhibitors could be on the market by 2004.

Newly synthesized drugs that selectively inhibit nonspecific inflammation are in pre-clinical trials. This inflammation, enabled by the protein "Factor D" often follows open-heart surgery. By blocking the natural action of Factor D, the immune system is prevented from overreacting, allowing the patient to recover more rapidly. The drug was designed from large, well organized crystals of the protein grown in space under the direction of the CMC and its corporate partner.

The Protein Crystallization Facility (PCF) payload, developed by the CMC flew on the STS-86 shuttle mission containing samples of human recombinant insulin. The quality of the space-grown crystals appears to be vastly superior to the earth-grown, control crystals. A better understanding of the molecular structure and the forces which hold the insulin molecules together may be important for improved diabetes therapy.

The CMC has flown Chagas disease proteins on the recent MSL-1 flight. This highly successful mission produced the best crystals of Chagas proteins ever obtained. Knowledge of the structure of this protein could lead to better treatment of this debilitating disease. An estimated 10 to 20 million people in Latin America, and a dramatically growing number of people in the U.S., are infected with the parasite that causes Chagas' disease.

Light Emitting Diode (LED) technology develop by the WCSAR for commercial investigations in space using the Astroculture plant chamber has been applied to the development of a new cancer treatnient. The LED's used in the plant chamber have been incorporated into a cancer treatment technique called photodynamic therapy, which is based on utilizing light sensitive, tumor fighting drugs activated by the LED's. Experiments just completed with animals indicate that when these special tumor-fighting drugs are illuminated with LEDs, the tumors are more effectively destroyed than with conventional treatments. The light source is compact and mechanically more reliable than other light sources used to treat cancer, such as lasers. *An* LED-based photodynamic therapy probe is expected to be on the market soon after clinical trials are completed.

Recombinant Interleukin-2 (rIL-2) (Brand name Proleukin) is in phase II clinical trials as a treatment for AIDS and for cancer. This drug was enabled by research performed by SBST and Chiron, an industry affiliate.

In FY 1997, the Liquid Phase Sintering metallurgical research experiment flew on the NASA/Mir program, utilizing a new concept called "defect trapping" in space to study defect formation in molten metal materials as they solidify as part of a project at the CMDS at the University of Alabama in Huntsville to improve the quality of U.S. cutting and finishing tools.

Ground based research in thin film growth at Space Vacuum Epitaxy Center (SVEC) has led to the development of the first-ever Type-II quantum cascade (mid-infrared) semiconductor laser for operation at room temperature. Applications include monitoring environmental trace gases both in space exploration and terrestrial environmental monitoring. This research is done jointly with Quantum Engineering Technology, Inc., Applied Optoelectronics, Inc. and JPL. In addition, SVEC's ground based research has also led to a collaboration with the Texas Medical Center/University of Texas Health Science Center to fabricate a ceramic optical detector that can be implanted into the eye to restore sight in people with various retinal dystrophies.

Researchers at MSFC conducting commercial experiments during parabolic aircraft flights have demonstrated that microgravity conditions can reduce or eliminate crystallization in certain optical fiber. This fiber has the potential to be 100 times more efficient than present silica fiber optics and could be utilized to produce laser surgery instruments, optical amplifier and other conirnunication equipment.

The Space Center for Medical Informatics and Applications was established at Yale University in June, 1997. Telemedicine test beds were established in the Ukraine as of September 1997. The first one will be to test a new 3-D ultrasound system and informatics transmission over the Internet. This test bed will include adaptability of the sensor array and ability to accurately transfer oncology data on children's thyroid cancer caused by the Chernobyl Disaster that occurred on April 26, 1986. The Center is finalizing plans for a Summer International workshop on Medical Informatics and Applications. European Space Agency (ESA), Centre D-Nationale Etudies Spatiale, the French Space Agency (CNES) and the Italian Space Agency (ASI), Egypt, Israel, and Brazil have been invited to participate. This center is leveraging a number of front-end investments from the Office of Naval Research and the Defense Advanced Research Projects Agency. The medical informatic technologies to be tested include astronaut vital signs monitors, 3-D imagers and biochemical monitors and remote surgery technologies.

The CSCs with their industrial partners will be preparing the research module mission for flight on STS-95. The commercial payloads schedule for this mission are listed above in the planned flights for FY 1999. Commercial research will be performed in the areas of biotechnology, agriculture and materials processing during this mission. The CSCs will expand collaboration with industrial affiliates in all research areas and continue to work to bring to market the products enabled by space research. The CSCs will continue to work with the OLMSA science programs to identify areas of potential collaborations, utilizing as many common hardware facilities as possible, as planning continues for the long duration research capability that will be provided by the ISS.

BASIS OF FY 1999 FUNDING REQUIREMENT

OCCUPATIONAL HEALTH RESEARCH FUNCTION

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Occupational Health Research (OHR) Function	200	700	700

PROGRAM GOALS

The Occupational Health Research function (OHR) consists of several well-defined constituent activities including: Occupational Medicine, Industrial Hygiene, Radiation Health, Physical Fitness, Employee Assistance Programs, Workers' Compensation, Nutrition and Food Safety, and Wellness and Health Education. Collectively, these constituent activities ensure the well-being and productivity of the NASA work-force. OHR has the primary responsibility for the control and elimination of harmful exposures of NASA employees to chemical, physical and biological agents, for the prevention of occupational disease and injury, and the promotion of optimal health, performance and productivity.

STRATEGY FOR ACHIEVING GOALS

The OHR function establishes policies and manages implementation of NASA-wide occupational and environmental health programs and services through the Agency Occupational Health Office located at KSC.

The primary program goals for FY 1998 and FY 1999 are centered around improving Agency OHR program effectiveness and efficiency via the following prograniniatic improvements: program standardization and automation; increased inter-center communication; International Organization for Standardization (ISO) compatible programs assessment; technical support center augmentation; and a training program development. The lead Center will investigate feasibility and implement where practical a consolidated occupational health contract. Interagency agreements will be leveraged for optimum utilization of expertise and services. Internal management boards, including the Occupational Health and Safety Executive Board, a Program Management Council, and Environmental Health and Occupational Medicine Program Boards will be formed. A Commercial Off-The-Shelf (COTS) health information management system will be selected and implemented. Standardized medical protocols will be developed and on-line networking and web based training will be initiated for all occupational health professionals.

MEASURES OF PERFORMANCE

Occupational Health and Safety conservation, Plan: 2nd Qtr. FY 1997 Actual: 1st Qtr. FY 1997	Establish a Board for the Agency to ensure Agency-wide uniformity of health Executive Board (OHSEB) and promotion programs and compliance with externally-mandated laws and regulations.
Agency Workers' Compensation Rates Plan: 1st Quarter FY 1999	Reduce NASA charge-back billing through the acquisition and implementation of a new case tracking data management system
Early Medical Diagnosis	Utilization rates of key preventive services such as medical surveillance, employee assistance Plan: 4th Qtr, FY 98 programs, and fitness centers are indication of positive risk factor interventions aimed at keeping the work-force healthy and productive.

ACCOMPLISHMENTS AND PLANS

Management of the OHR function was successfully transferred to KSC as Lead Center in FY 1997. Comprehensive on-site program assessments were completed at each NASA center. The Occupational Health and Safety Executive Board (OHSEB) was chartered and includes a subcommittee on Health, Environmental Management, and Safety. NASA completed the year without any significant regulatory actions relative to occupational health issues. No major mishaps occurred relative to occupational health risk factors. A new data management system was selected and implemented for the Agency workers' compensation program. A worldwide Medivac capability for all NASA employees and contractors on foreign deployment was established. A major OHR initiative was begun with the Health Enhancement Research Organization to determine the comparative impact of known cardiovascular risk factors to enable best allocation of limited resources. Agency-wide training was provided relative to life skills management for a changing world and a follow-on report commissioned to the Duke University School of Behavioral Medicine. An Agency-wide lead exposure protocol was developed and new OHR policy documents were developed for all major functional areas.

FY 1998 plans for the OHR function include the optimum utilization of expertise and services available via interagency agreements. Presentation by Duke University to OHSEB on results of Agency-wide Life Skills focus groups, for approval of subsequent pilot project and evaluation to be conducted at least at one Center. Formation and effective utilization of a Program Management Council and an Occupational Medicine Program Manager's Board. The Lead Center will develop for approval, a standardized medical surveillance protocol and on-line networking of occupational health professionals at the NASA Centers. Program assessment methodology will be revised for ISO compatibility. A COTS health information management system will be selected. They will continue to build-up and staff a Technical Support Center to leverage outside expertise and reduce duplication of effort. The OHP plans to continue and expand the Health Enhancement Research Organization and American Heart Association affiliations to produce gender-specific data for enhanced preventive program planning. Efforts will be directed towards working with the Office on Women's Health to improve program effectiveness for females.

FY 1999 plans will continue to apply state-of-the-art preventive medicine and environmental health approaches to health conservation and health promotion in all environments via NASA worldwide Medivac capability and the utilization of interagency agreements. The OHR function will investigate the feasibility and subsequent implementation, where practical, of a consolidated occupational health contract. A COTS health information management system will be implemented. The Lead Center will develop a standardized preventive medical examination protocol for approval and implementation. Duke University pilot will be evaluated for implementation Agency-wide to enhance productivity and coping skills, and decrease the potential for accident, and errors.

BASIS OF FY 1999 FUNDING REQUIREMENT

SPACE MEDICINE RESEARCH FUNCTION

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Space Medicine Research (SMR) Function	3,600	6,800	6,900

PROGRAM GOALS

The Space Medicine Research (SMR) function is focused on the development of policies and requirements for clinical care and medical research in support of human space flight. Processes have been established to develop these policies and requirements, which provide guidance for developing systems and technology to ensure crew health and minimize mission impact. NASA leads the world in developing and implementing cutting edge space medicine and crew perfomiance programs.

STRATEGY FOR ACHIEVING GOALS

SMR consists of several projects to ensure the health, safety, and performance of space flight crew members on all U.S. missions: Shuttle, NASA/Mir, the ISS and the exploration missions. The SMR function is responsible for development of policies and requirements to maintain and provide medical support to optimize the health, safety and productivity of our astronauts in space. The function also develops technologies and applications including telemedicine. To achieve the program goals, several activities have been established, which are investments in technologies that will enable NASA to meet the challenges of human space flight. In addition, these technologies are being utilized today to enhance our abilities to provide medical care and medical education to NASA employees regardless of their location. An Agency-wide strategic plan for telemedicine lias been developed and will serve as a guide in the development, adaptation, and application of new technologies through partnerships with academia and industry by way of commercial space centers.

Contractor and Center Support

JSC and Headquarters are the principal Centers involved in the SMR function. JSC has been designated as the lead center responsible for the SMR function. ARC and LeRC are key Centers in the development of communications and computer technologies for the support of NASA's Spacebridge to Russia, an Internet-based telemedicine testbed. JSC will manage telemedicine efforts in support of medical operations activities for the Human Space Flight Program. Wright State University School of Medicine, the Texas Medical Center, and the University of Texas Medical Branch at Galveston, are the major academic institutions in the SMR program.

MEASURES OF PERFORMANCE

Multilateral Medical Policy Board Plan: 4th Qtr FY 1997 Actual: Under review	Establish and baseline a document for the Multilateral Medical Policy Board (MMPB) which validates medical requirements, standards, protocols, and flight rules for the International Space Station Program.
Telemedicine Instrumentation Pack Plan: 2nd Qtr FY 1998	The JSC developed Telemedicine Instrumentation Pack (TMIP) will fly on the Space Shuttle (STS-89) for inflight evaluation. Once proven, the TIMP will augment inflight medical operations activities on the ISS.

SMR prograni is in the process of refining criteria for measuring perforniance. Select criteria include: the conveyance of technology; protocols and procedures for terrestrial applications; arid overall fitness of humans in space and their ability to do productive work by measuring the effectiveness of medical systems, countermeasures, and standards. One such measure of perfomiance is the effectiveness of microgravity counternieasures.

In order to conduct human exploration and lo provide safe and affordable access and presence in space, we must understand and control the effects of microgravity on human health and function. Ongoing research and expanded experience, especially on the ISS, will help us iniprove astronaut performance and reduce the time required for astronauts to recover full functions following long-duration missions. OLMSA will track aggregate countermeasures effectiveness using two indices. Each index will include values ranging from one to five. The post-flight Rehabilitation Index will be used to evaluate crew health on return to earth based upon the time it takes to rehabilitate and return to space flight duty status. A second rating scale will be based upon deviations from planned mission timelines which are caused by biomedical and/or environmental concerns. Values for both indices will be assigned and documented by HEDS for each crew-mission. Values will be reviewed by the Aerospace Medicine arid Occupational Health Advisory Subcommittee of the NASA's Life and Microgravity Sciences and Applications Advisory Committee. Average ratings will be reported for each fiscal year.

ACCOMPLISHMENTS AND PLANS

During FY 1997, SMR successfully provided guidance to the operational medicine community at JSC for operational medical support for Shuttle missions and the long-duration missions to the Russian Space Station Mir. Management of the function was transferred to JSC as the lead center. The Space Medical Monitoring and Countermeasure (SMMAC)project supported the operational programs (Shuttle/NASA/Mir/ISS) through the refinement of medical requirements and assessment of medical risks, establishment of priorities for medical research, and development of medical flight policies in support of each of the space flight programs. Several teleniedicine technologies, including the Spacebridge to Russia, World Wide Web-based electronic patient record and the Telemedicine Instrumentation Pack, were pursued by the extramural community for commercialization. The technologies have proven to be effective tools as significant adjuncts to the delivery of medical care, access to information on global health, and medical education. The SMR function developed and baselined an Agency wide strategic plan for telemedicine.

During FY 1998, the SMR function will continue to support the needs of the operational medicine community for Shuttle and ISS missions. The SMMAC project activities will continue in support of all U.S. space flight programs including Shuttle, NASA/Mir, and the ISS. A Clinical Care Development Project will be established for evaluation and refinement of requirements for the delivery of clinical care for inflight space operations. Specifically, to ensure the timely availability of adequate procedures, protocols, and countermeasures to maintain and enhance human health and performance during space flight. The Agency Strategic Plan for Teleniedicine will be implemented through partnerships with the NASA Centers and the Commercial Space Center (CSC) for Medical Informatics and Technology at Yale University. Mature teleniedicine activities, including the Internet-based telemedicine test bed, Spacebridge to Russia, and the Space Bioniedical Center for Research and Training will be transitioned to the CSC for Medical Informatics and Technology at Yale University. The NASA JSC-developed Telemedicine Instrumentation Pack will be evaluated during the STS-89 Shuttle flight. Evaluation of emerging technologies in infomiation and telecommunications for application to teleniedicine will continue. The SMR function will work closely with the American Medical Association to define and conduct investigations in: (1) medical risk assessment and evidence-based medicine; (2)telemedicine accreditation standards for space exploration; and (3)certification of continuing medical education (CME) credit for NASA CME activities and other certification programs for U.S. and international participants. NASA and its international partners for ISS will further refine the processes for addressing medical policy and medical care through the MMPB.

During FY 1999, the SMR function will continue to support the needs of the operational medicine community for Shuttle and ISS missions. The outcomes of the SMMAC project activities will foster refinements in systems, protocols, and procedures that will support all U.S. human space flight programs including Shuttle, the ISS, and future exploration missions. The Clinical Care Development Project will continue to support the ongoing evolution of medical care for space flight, which will be specific to mission needs and challenges. Mature teleniedicine activities, including the Internet-based telemedicine test bed, Spacebridge to Russia and the Space Bioniedical Center for Research and Training, will continue to be conducted through the CSC for Medical Informatics and Technology at Yale University. Medical operations activities inflight will be augmented with additional teleniedicine capability, including the Telemedicine Instrumentation Pack and those technologies, procedures and protocols that result froni the CSC for Medical Informatics and Technology. Efforts of the MMPB and Multilateral Medical Operations Working Group will continue. Investments in collaborative activities with academia, other agencies, and industry in the application of emerging technologies in comniunications and information systems to health care for space flight will continue.

BASIS OF FY 1999 FUNDING REQUIREMENT

MISSION INTEGRATION FUNCTION

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Mission Integration (MI) Function	24,200	4,900	1,700

PROGRAM GOALS

The goals of MI function are twofold: (1) provide physical, analytical, and operations integration support to achieve NASA mission objectives for the science and technology communities; and (2) ensure integrated scientific, technological, and commercial user advocacy and coordination of requirements for the next generation of space laboratories, the ISS. These activities include the integration, coordination and policy planning and analysis for International research activities within OLMSA.

STRATEGY FOR ACHIEVING GOALS

In order to meet the function goals and objectives, NASA performs the mission planning, integration, and execution of all NASA Spacelab, Spacehab, the NASA/Mir Research Program (NMRP), and other attached Space Shuttle payloads to carry out a wide variety of space research. The function also supports the common small science payloads that use locker spaces in the Space Shuttle's lower crew compartment. Activities include system management and engineering development of flight support equipment and software; development of interface hardware: payload specialist training and support; integration of the science payloads with the Spacelab system; payload flight operations: and data dissemination to experimenters. Mission management activities are dependent upon the specific mix of missions in a particular year.

In addition, through this function, NASA carries out systems engineering efforts to develop and evaluate strategies and processes for satisfying current and future research mission objectives. These tasks not only address the current Space Shuttle/Spacelab mission integration processes, but, based on this knowledge base, they define and support new effective and efficient processes and tools for carrying out integrated research advocacy, requirements coordination, mission planning and operations for future space platforms. In particular, the program is investigating ways to apply the engineering and operations lessons learned in the Spacelab program and the NMRP to the ISS program to achieve greater efficiencies.

Center and Contractor Support

The principal NASA Centers which conduct activities in support of this function are JSC, KSC, and MSFC. MSFC provided the analytical integration and operations level project management support for the USMP-4, flown in the first quarter of FY 1998. KSC provided the physical hardware science payload integration project management support for the NASA science payloads USMP-4 flights. In FY 1998, JSC will provide the analytical integration and operations level project nianagenient support for the remaining two NMRP missions (NASA/Mir 8 and NASA/Mir 9, scheduled to be launched in the first and second quarters respectively), the Neurolab mission (scheduled to be launched in the third quarter) and the first of two DOE-sponsored Alpha Magnetic Spectrometer (AMS) flights (scheduled to be launched in the third quarter). KSC will provide the physical hardware science payload integration project management support for Neurolab.

In FY 1998, the primary contractors that will be supporting the function at the Centers are: Lockheed-Martin at JSC; the McDonnell Douglas Corporation's Payloads Ground Operations Contract (PGOC) at KSC; and Teledyne-Brown Engineering at MSFC. At JSC, Lockheed-Martin provides payload mission integration support for the missions managed by the JSC. At MSFC, Teledyne-Brown provides payload mission integration support for the missions managed by MSFC. At KSC, the primary PGOC functions include: processing flight hardware experiments for Spacelab and partial payloads, manifest scheduling and work control support, logistics support and sustaining engineering modifications to facilities and systems, and computational services for the Payload Operations Computer Network.

In FY 1999, Spacehab will begin to provide payload management and integration for research payloads on STS-95 and the STS 107 missions. It is anticipated that the level of contractor support at the Centers in FY 1999 will be significantly reduced concomitant with the conclusion of the Spacelab program.

MEASURES OF PERFORMANCE

The most significant measure of performance of the function is the provision of an integrated system that ensures successful accomplishment of the science payload objectives. Although not directly responsible for the success of a particular experiment, the mission management organization is responsible for ensuring that all necessary planning arid integration of the collected set of instruments have been comprehensively completed and fully coordinated so that the experimental hardware in concert with flight crew performance and ground control direction have the opportunity to conduct the planned science activities. Science payload objectives vary considerably depending upon the type of mission supported (module missions, pallet/MPESS missions or Space Shuttle Middecks) and the type of scientific investigations performed (microgravity, life sciences, earth and stellar observations). Depending upon the type of payload, performance is measured in terms of the number of primary missions and the number of middeck missions successfully flown as scheduled and the successful accomplishment of the science payload objectives:

	FY 1997		FY 1998		FY 1999
	plan	Actual	plan	Revised	Plan
Spacelab/Pallet/Shuttle Attached Missions	3	3	3	3	1
Mir Missions	3	3	2	2	--
Middecks/Small Payloads	8	9	12	6	4

ACCOMPLISHMENTS AND PLANS

ORFEUS-SPAS 2 Launch
Plan: 1st Qtr FY 1997
Actual: 1st Qtr FY 1997

The second flight of the Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer Shuttle Pallet Satellite (ORFEUS-SPAS-2) is an astronomical telescope for observations at very short wavelengths in two spectral ranges, the far ultraviolet (FUV) and the extreme ultraviolet (EUV). These spectrometers were mounted on the German built deployable/retrievable ASTRO-SPAS carrier.

MSL-1 Launch
Plan: 2nd Qtr FY 1997
Actual: 4th Qtr FY 1997

The MSL-1 focused on microgravity combustion and international research in microgravity materials science. Three new microgravity combustion experiments used two new, large research facilities constructed for this mission. The mission was reflown due to Space Shuttle hardware anomalies.

CRISTA-SPAS 2 Launch
Plan: 4th Qtr FY 1997
Actual: 4th Qtr FY 1997

The second flight of the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere Shuttle Pallet Satellite (CRISTA-SPAS-2) is a set of spectrometers which was used to measure the constituents of earth's middle atmosphere. These spectronieters are mounted on the German built deployable/retrievable ASTRO-SPAS carrier.

USMP-4 Launch Plan: 1st Qtr FY 1998 Actual: 1st Qtr FY 1998	This USMP-4 mission performed materials processing and other experiments in the microgravity space environment with inflight monitoring of phenomena, saniple production, and postflight analysis of samples. Such activities are expected to significantly advance the basic knowledge of materials science and help develop better products and technology for use on earth and in space.
Neurolab Launch Plan: 3rd Qtr FY 1998	This mission will perform international research in brain function and behavior, including research on the autonomic nervous function, sleep regulation, vestibular physiology, developmental neurobiology, and sensorimotor function.
Alpha Magnetic Spectrometer Launch Plan: 3rd Qtr FY 1998	This Department of Energy (DoE) sponsored AMS payload will fly twice, first on the Space Shuttle in 1998 and later on the ISS.. AMS will search for cosmic sources of antimatter and missing matter (Co-manifested With NASA/Mir-9).
STS-95/Discovery Research Mission Plan: 1st Qtr FY 1999	This is the first "pathfinder" research flight (STS-95) being planned as part of the initiative to induce commercial investment in Space. A portion of the total estimated payload resources for each of these planned flights will be made available to a carrier contractor who will "market" this capability directly to the ISS partners. The mission will include peer-reviewed research in the Life and Microgravity sciences as well as conimercial research,

In FY 1997, the organization provided mission management support to the launch of the MSL-1 mission in addition to 3 flights to Mir (discussed within the Space Station program narrative.) The organization also provided program coordination for the second flights of the CRISTA-SPAS-2 and the OFWEUS-SPAS-2 missions, both launched in FY 1997. In FY 1997, systems engineering efforts continued to support methodologies for advocacy arid coordination of U.S. research requirements and iniplementation of processes and tools for mission planning for U.S. payloads on the future space platform, the phase II and III of the ISS. Space Station planning and integration efforts have intensified as the First Element Launch date of the ISS approaches (July 1998). Spacelab-related activities were sharply reduced in FY 1997, because the Spacelab modules fly for the last time in early 1998.

During FY 1998, the organization will provide support for four Shuttle missions: the Neurolab mission, USMP-4, the two final flights in the NASA/Mir Research Program and the first DOE-sponsored AMS mission (co-manifestation on NASA/Mir-9). The Neurolab mission will be the final Spacelab mission and marks the conclusion of the very successful Spacelab program. In addition, mission management support will be provided for the first in a series of two research missions (STS-95) to provide a transition between the completed Shuttle missions and onset of significant research capability on-board the ISS. These missions are also intended to be pathfinders for future commercial involvement in carrying out orbital research, and will be implemented through commercially provided carriers and carrier integration services.

During FY 1999, mission management support will continue for the second DoE sponsored AMS mission planned for the ISS. Space Shuttle "pathfinder" research missions will provide continuing space access to the science and commercial programs until a substantive research capability is available on the ISS in 2001. The first of these, STS-95, in October 1998, is in detailed implementation planning and will use commercially provided carrier and integration services. The other mission, will fly in the third quarter of FY 2000 and fly microgravity, life sciences, and commercial research payloads. These two flight opportunities are independent of the ISS Research Program and have been advertised to the ISS partners as opportunities to allow them to begin ISS-type flight experience earlier than planned in the ISS Program. The first mission, on STS-95, will include a single module for accommodating research hardware and will be provided by SPACEHAB, Inc. To offset costs, SPACEHAB Inc. has been allocated some of the carrier capability to market to non-NASA customers, including ISS partners who wish to take advantage of this research opportunity before they have access to ISS utilization. As part of the initiative to induce commercial investment in Space, a portion of the total estimated payload resources for each of these flights will be made available to the carrier contractor who will "market" this capability directly to the ISS partners. In return, the costs for each mission chargeable to NASA for its payloads would be offset. Provided this strategy is tested successfully in the first flight, STS-95, it is considered to be a "pathfinder" in terms of the space flight commercialization process.

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF EARTH SCIENCE | **EARTH SCIENCE**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
Earth Observing System	582,200	704,600	659,100	SAT 3-8
Earth Observing System Data Information System	234,600	209,900	256,600	SAT 3-25
Earth Probes	61,800	48,600	85,900	SAT 3-29
Applied research and data analysis	393,300	364,400	365,400	SAT 3-33
Global observations to benefit the environment	5,000	5,000	5,000	SAT 3-46
Launch services	84,700	34,800	---	SAT 3-48
Total	1,361,600	1,367,300	1,372,000	

Distribution of Program Amount by Installation

	FY 1997	FY 1998	FY 1999
Johnson Space Center	25	---	---
Kennedy Space Center	4,800	3,000	---
Marshall Space Flight Center	19,537	11,300	7,400
Stennis Space Center	73,163	21,700	20,000
Ames Research Center	22,900	11,500	8,300
Dryden Flight Research Center	5,707	12,800	15,700
Langley Research Center	45,326	32,900	26,200
Lewis Research Center	35.830	16,200	---
Goddard Space Flight Center	1,024,314	1,138,200	1,179,400
Jet Propulsion Laboratory	88,410	76,700	70,000
Headquarters	41.588	43,000	45.000
Total	1,361,600	1,367,300	1,372,000

OFFICE OF EARTH SCIENCE

PROGRAM GOALS

The purpose of NASA's Earth Science Enterprise is to understand the total earth system and the effects of natural and human-induced changes on the global environment. Earth Science is pioneering the new interdisciplinary field of research called earth system science, born of the recognition that the earth's land surface, oceans, atmosphere, ice sheets and biota are both dynamic and highly interactive. It is an area of research with immense benefits to the nation, yielding new knowledge and tools for weather forecasting, agriculture, water resource management, urban and land use planning, and other areas of economic and environmental importance. In concert with other agencies and the global research community, Earth Science is providing the scientific foundation needed for the complex policy choices that lie ahead on the road to sustainable development. Earth Science has established three broad goals: 1) expand scientific knowledge of the earth system using NASA's unique capabilities from the vantage points of space, aircraft and *in* situ platforms; 2) disseminate information about the earth system: and 3) enable productive use of Earth Science program science and technology in the public and private sectors. The Earth Science Enterprise has evolved from what was previously called the Mission to Planet Earth Enterprise.

STRATEGY FOR ACHIEVING GOALS

The pursuit of earth system science would be impractical without the continuous, global observations provided by satellite-borne instruments. Earth Science comprises an integrated slate of spacecraft and in situ measurement capabilities: data and information management systems to acquire, process, archive and distribute global data sets; and research and analysis programs to convert data into new knowledge of the earth system. Numerous users in academia, industry, federal, state and local government tap this knowledge to produce products and services essential to achieving sustainable development. Earth Science is NASA's contribution to the U. S. Global Change Research Program (USGCRP), an interagency effort to understand the processes and patterns of global change.

The Earth Observing System (EOS), the centerpiece of Earth Science, is a program of multiple spacecraft (the AM, PM, Chemistry, Landsat-7, and follow-on and supporting technology) and interdisciplinary science investigations to provide a 15-year data set of key parameters needed to understand global climate change. The first EOS satellite launches begin in 1998. Preceding EOS are a number of individual satellite and Shuttle-based missions which are helping to reveal basic processes. The Upper Atmosphere Research Satellite (UARS). launched in 1991, collects data on atmospheric Chemistry. The Total Ozone Mapping Spectrometer (TOMS) instruments, launched in 1978, 1991, and 1996, measure ozone distribution and depletion. Two TOMS instruments were launched in 1996, one on the Japanese Advanced Earth Observing System (ADEOS) mission and the other on a dedicated U. S. earth probe. France and the U. S. collaborated on the Ocean Topography Experiment (TOPEX/Poseidon), launched in 1992, to study ocean topography and circulation. The NASA Scatterometer (NSCAT) mapped ocean winds for one year prior to an on-orbit failure of the Japanese ADEOS-I spacecraft on June **30,** 1997. In 1997, the Tropical Rainfall Measuring Mission (TRMM) was launched to provide the first-ever measurements of tropical precipitation. Complementing EOS will be a series of small, rapid development Earth System Science Pathfinder (ESSP) missions to study emerging science questions and to use innovative measurement techniques in support of the 15-year mission of EOS. The first two ESSP missions, Vegetation Canopy Lidar (VCL) and Gravity Recovery and Climate Experiment (GRACE), were selected and are scheduled for launch in 2000 and 2001, respectively.

Data from Earth Science missions, both current and future, will be captured, processed into useful information, and broadly distributed by the EOS Data Information System (EOSDIS). EOSDIS will ensure that data from these diverse missions remain available in active archives for use by current and future scientists, Since these data are expected to find uses well beyond the Earth Science research community. EOSDIS will ultimately be accessible by environmental decision-makers, resource managers, commercial firms, social scientists and the general academic community, educators, state and local government--anyone who wants the information. Following the recommendation of the National Research Council, NASA is exploring the creation of a federation of Earth Science information partners in academia, industry and government to broaden the participation in the creation and distribution of EOSDIS information products. As a federation pilot project, 24 organizations were competitively selected in December 1997 to become Earth Science Information Partners (ESIPs) to develop innovative science and applications products.

The intellectual capital behind Earth Science missions, and the key to generating new knowledge from them, is vested in an active program of research and analysis. Over 1,700 scientific investigations from nearly every U. S. state are funded by the Earth Science research and analysis program. Scientists from seventeen other nations, funded by their own countries and collaborating with U. S. researchers, are also part of the Earth Science program. These researchers develop earth system models from Earth Science data, conduct laboratory and field experiments, run aircraft campaigns, develop new instruments, and thus expand the frontier of our understanding of our planet. Earth Science-funded scientists are recognized as world leaders in their fields, as exemplified by the award of the 1995 Nobel Prize in chemistry to the two scientists who investigated the threat of cholorflorocarbons to upper atmospheric ozone. The research and analysis program is also the basis for generation of application pilot progranis which enable universities, commercial firms, and state and local governments to turn scientific understanding into economically valuable products and services.

The first Earth Science Science Research Plan was published in 1996. The plan laid out a strategy for study in five earth system science areas of maturing scientific understanding and significant societal importance: land-cover and land use changes: short-term climate events, natural hazards research and applications; long-term climate change research: and atmospheric ozone research. The plan also outlines some twenty related areas of research which round out the Earth Science contribution to earth system science.

The challenges of earth system science, sustainable development, and mitigation of risks to people, property and the environment from natural disasters, require collaborative efforts among a broad range of national and international partners. As mentioned above, the USGCRP coordinates research among thirteen U. S. government agencies, NASA is by far the largest partner in the USGCRP, providing the bulk of USGCRP's space-based observational needs. NASA has extensive collaboration with the National Oceanic and Atmospheric Administration (NOAA) on short-term climate event prediction. Earth Science is the responsible managing agent in NASA for the development of NOAA's operational environmental satellites. NOAA, NASA, and the Department of

Defense (DoD) jointly work to achieve the convergence of civilian and military weather satellite systems. NASA collaborates with the U. S. Geological Survey (USGS) on a range of land surface, solid earth and hydrology research projects. NASA, NOAA and USGS collaborate in the Landsat-7 program, and NASA, DoD and USGS are working together on a third flight of the Shuttle Radar Laboratory modified to yield a digital terrain map of most of the earth's surface. NASA participates in the World Climate Research Program, the International Geosphere/Biosphere Program, and the ozone assessments of the World Meteorological Organization. Most of Earth Science's satellite missions have international participation, ranging from simple data sharing agreements to joint missions involving provision of instruments, spacecraft, and launch vehicles. In the past two to three years over 60 international agreements have been concluded and more than 40 more are pending. In some capacity, Earth Science programs involve international partners from over 35 nations, including Argentina, Armenia, Australia, Belgium, Brazil, Canada, Chile, China, Denmark, Egypt, France, Germany, India, Israel, Italy, Japan, Mongolia, Russia, South Africa, Ukraine and others..

International cooperation is an essential element in the Earth Science program. Earth Science addresses global issues and requires international involvement in its implementation and application. Acquiring and analyzing the information necessary to address the science questions is a bigger task than a single nation can undertake. Furthermore, the acceptance and use of the scientific knowledge in policy and resource management decisions around the world require the engagement of the international scientific community. Global data and global participation are needed to devise a global response to environmental change. In addition, integrating our complementary science programs can result in positive fiscal benefits to the NASA program. For this reason, NASA has sought and nurtured international partnerships spanning science, data and information systems, and flight missions.

NASA has adopted an evolutionary approach to fulfilling Earth Science mission and goals. Out of this approach came the Earth Science involvement in the New Millennium Program which conducts the development and flight demonstration of advanced, smaller instruments for the EOS second series. Our basic approach has been endorsed by the National Research Council (NRC) through its Board on Sustainable Development.

In 1997, NASA conducted the first Biennial Review of Earth Science. The Biennial Review focused on the following five key areas:

- Program balance and the restoration of research and analysis funding
- EOSDIS Core system
- EOS Chemistry-1 mission architecture
- Technology infusion strategy
- Implementation of the Earth Science program after 2002

The first three key areas address issues remaining in the time-frame of the first series of the Earth Observing System. The latter two key areas look to the future, and enable a fundamentally different and vastly more flexible means of planning and implementing Earth System Science missions. While the first Biennial Review focused on five key topics, the philosophy underlying the Review was the need to extend the evolutionary approach. In the planning during 1996, the Earth Science Enterprise moved from a commitment to instruments that obtain long term data sets to a commitment to the actual measurements, allowing the instruments to change driven by advances in technology. Also in 1995 planning, the science community began to distinguish between “monitoring”and “process”measurements in the set of 24 EOS measurements. The former are needed continuously over the lifetime of the program to identify trends in key Earth Science phenomena, while the latter are needed once or intermittently to understand the underlying physical, chemical and biological processes.

The scientific objectives of the Earth Observing System remain the same: the strategy for implementation and the integration of EOS with the other elements of Earth Science is evolving. The product of the Biennial Review was reviewed by a panel of external experts, and largely serves as the basis for Earth Science’s FY 1999 budget request.

This budget preserves the baseline program presented in the FY 1998 budget, and wholly implements the Biennial Review recommendations as discussed below. The efficiencies found through the Biennial Review process have preserved measurement continuity and also enabled several new initiatives which include QuikScat, LightSAR and an enhanced commercial research program at Stennis Space Center.

Program *Balance:* The requested funding provides for a robust science program, restoring research and analysis funding to about the FY 1994 level. These additional funds will allow enhancements to core disciplinary science, interdisciplinary science, new Office of Science and Technology Policy (OSTP)/USGCRP initiatives in regional impacts of global change, and the airborne science program. They will allow Earth Science to accept even more research proposals rated excellent and very good in the peer review process. At this funding level, Earth Science can pursue the analysis of the emerging remote sensing data on the Antarctic, provide greater support for the U. S. Weather Research Program, and sponsor needed research in the role of aerosols in climate variability.

EOSDIS Core System: Recommendations of the EOSDIS review group of users both inside and outside of the Earth Science program were adopted as Biennial Review decisions. These included:

- Establishing a Data Processing Resources Board (DPRB) and a science-led peer review group lo permit an interactive dialogue among users and EOSDIS project managers on requirements, capabilities, and cost.
- Processing all satellite data to Level 1 (the level useful to researchers and commercial interests), and phase-in the capability to generate the higher level data products based on a reassessment of early science needs.
- Creation of selected interdependent data sets to be phased in over a two-year period.
- Re-aligning the Federation experiment to achieve a more flexible mix of production, archival arid distribution capabilities.

EOS Chemistry-1 Mission Architecture: The external panel of experts assessing the Biennial Review recommended that the Chemistry-1 baseline architecture using the common spacecraft be implemented. The experts found that the baseline approach is the most cost-effective way to achieve the EOS chemistry measurements. The approach preserves the important synergism between the measurements to be made by the Tropospheric Emission Spectrometer and the Microwave Limb Sounder instruments.

Technology *Infusion* Strategy: The Biennial Review recommended development of a strategy to select technology development tasks based on science needs and to fund technology development that supports more efficient and cost-effective instrument implementation. This strategy integrates the efforts of the core technology and new millennium programs (both shared with the Space Science Enterprise), the instrument incubator program, and the high performance computing and communications program (shared with all enterprises).

Implementation of Earth Science Program After 2002: Earth Science has adopted a new model for mission planning. Advances in spacecraft and instrument technology as well as in scientific understanding have made new forms of mission design and implementation possible. The spectrum of possibilities includes highly specific missions integrated by NASA project managers, purchases of commercial remote sensing data, and missions selected from broad agency announcements. Future missions will be planned and developed on a schedule that allows time for learning from the previous series of missions.

Key features of implementation of post-2002 missions include:

- Future missions will be planned to implement the measurement requirernents of the five science themes: these requirements will evolve in response to emerging science questions.
- New partnerships will be sought in the international, interagency and commercial arenas.
- A principal investigator-driven solicitation approach will be utilized as much as is appropriate.
- Shorter development times will result from increased focus on instrument technology development and increased reliance on commercial spacecraft.

The EOS AM-1 will be launched in 1998. This mission will provide key measurements that will significantly contribute to our understanding of the total earth system. The AM-1 instrument complement will obtain infomiation about the physical and radiative properties of clouds, air-land and air-sea exchanges of energy, carbon, and water, measurements of trace gases, and volcanology.

Landsat-7 is scheduled for launch ahead of the commitment date of December 1998. Landsat-7 will carry a single instrument, the Enhanced Thematic Mapper Plus (ETM+), which will make high spatial resolution measurements of land surface and surrounding coastal regions. This mission will provide data continuity with previous Landsat measurements. Landsat data is used for global change research, regional environmental change studies, national security and other civil and commercial purposes.

With the EOS main missions, such as AM-1 and Landsat-7 that will be launched in 1998, NASA will begin to turn flight data into information. In addition to the EOSDIS that will produce data products for a wide range of users, NASA will participate in a government-wide effort to understand our planet in the twenty-first century. The work is called the Digital Earth and will fuse Earth Science data, socio-economic data, and other data sets that can be "geo-referenced" and used to communicate to scientists and non-scientists a tremendous amount of information using data visualization.

The first of two new cooperative missions with the Russian Space Agency (RSA), the Meteor-3M(1) Stratospheric Gas and Aerosol Experiment (SAGE III) mission, will be launched in 1999. This mission will collect global profiles of key gaseous species from the troposphere to the mesosphere. The science team will investigate spatial and temporal variability and investigate the effects of aerosols and clouds on the earth's environment, The Russian METEOR-3M(2) spacecraft will carry the last planned TOMS into orbit in 2000, providing continuity in the essential measurement of the total column of ozone in the stratosphere

Phase 1 of the commercial data purchase will be carried out by the eleven comniercial vendors selected in November 1997. The scientific evaluation of their example data products will be made by the science community. The data sets providing high science value will be selected for Phase 2, which is the commercial provision of scientifically useful data sets.

Discussion of land cover/land use change science requirements in the Landsat-7 & AM-1 era will be initialized in the Spring of 1998 with the intent of giving potential commercial providers early insight into Earth Science future data needs. The goal is Lo have EOS second series data requirements met by commercial providers where possible and cost-effective.

In late 1998, QuikScat will be launched to fill the gap in critical sea surface wind data resulting from the on-orbit failure of the Japanese ADEOS-I spacecraft in June 1997. We have accelerated the availability of components of the Seawinds instrument originally planned for launch on Japan's ADEOS II mission as a QuikScat instrument. The launch of QuikScat will reduce a gap of as great as *3* years in sea winds data from the loss of ADEOS-I by as much as 24 months. Japan has yet to decide on the timing and form of an ADEOS II mission (or missions), but Earth Science still intends to fly a Seawinds instrument in that context as the follow-on instrument to QuikScat. This will enable continuity of the ocean winds data set for its many users. In parallel to this development effort, a data buy solicitation for ocean and wind vector data is being initiated.

The measurements to be made by these and other future Earth Science missions as well as current on-orbit missions provide data products that are used extensively in the Earth Science program. The program encompasses over 1,700 scientific activities at universities, research laboratories, and government research organizations. These activities are providing an ever increasing scientific understanding of global environment and the effects of natural and human sources of change.

$50 million in the FY 1998 budget has been reserved for the potential use of Space Station, depending on the outcome of future appropriation action. All Earth Science program commitments, products, and scheduled events can be met even after the $50 million appropriations transfer to Human Space Flight.

BASIS OF FY 1998 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
AM-1	82,800	44,900	6,100
PM-1	147,500	175,900	124,200
Chemistry-1	46,600	100,600	140,900
Special spacecraft	65,500	101,200	152,100
QuikScat	35,000	34,500	7,900
Landsat-7	78,800	52.600	2,000
Algorithm development..	75,900	96,300	122,900
Technology infusion	50.100	93.100	78,200
(New millennium program)...	(37,400)	(66,900)	(52,700)
(Sensor & detector technology)....................................	(5,500)	(5,500)	(5,500)
(Instrument incubator)	(7,200)	(20,700)	(20,000)
EOS Follow-on	---	5,500	24,800
Total,,..	582,200	704,600	659,100

PROGRAM GOALS

The overall goal of the Earth Observing System (EOS) is to advance the understanding of the entire earth system on a global scale by improving our knowledge of the components of the system, the interactions between them, and how the earth system is changing. The EOS data will be used to study the atmosphere, oceans, cryosphere, biosphere, land surface and solid earth, particularly as their interrelationships are manifested in the flow of energy and in the cycling of water and other chemicals through the earth system.

The EOS program mission goals are: (1) to create an integrated, scientific observing system emphasizing climate change, that will enable multi-disciplinary study of the earth's critical, life-enabling, interrelated processes; (2) to develop a comprehensive data information system, including a data retrieval and processing system; (3) to serve the needs of scientists performing an integrated multi-disciplinary study of planet earth and to make Earth Science data and information publicly available; and, (4) to acquire and assemble a global database for remote sensing measurements from space over a decade or more to enable definitive and conclusive studies of earth system attributes.

STRATEGY FOR ACHIEVING GOALS

The EOS contributes directly to accomplishing the goal of understanding global climate by providing a combination of observations made by scientific instruments, which will be integrated with the EOS spacecraft, and the data received, archived, processed, and distributed by the EOSDIS. The selection of scientific priorities and data products responds directly to the USGCRP global change science priorities and the assessment by the Intergovernmental Panel on Climate Change of the scientific uncertainty associated with global change.

The three main EOS spacecraft that will support observations by the scientific instruments include the morning (AM), afternoon (PM), and Chemistry series. Beginning in 1998, 2000, and 2002 respectively, the satellites in this first series will be flown for a period of six years to begin to obtain, at a minimum, a data set that will span fifteen years. Additional observations will be provided by the Landsat-7 mission beginning in 1998. Data continuity for the measurements these missions produce will be maintained through the EOS follow-on program.

Nearly all key EOS missions include international contributions. For example, the AM-1 spacecraft will fly an instrument from Canada (Measurements of Pollution of the Troposphere (MOPITT)) and one from Japan (Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)); PM-1 will include the Japanese Advanced Microwave Scanner Radiation (AMSR) instrument and the Humidity Sounder for Brazil (HSB). In addition, numerous agreements have been signed for joint data exchange and distribution, including cooperation in EOSDIS.

EOS program planning began in 1983 with the definition of the science and mission requirements by the EOS Science and Mission Requirements Working Group (SMRWG). The SMRWG charter was to examine the major Earth Science questions for the 1990's and to define the requirements for low-earth-orbit observations needed to answer these questions on a comprehensive multi-disciplinary basis. The SMRWG's report, issued in 1984, listed five basic recommendations concerning Earth Science in the 1990's:

- A program must be initiated to ensure that the present time series of Earth Science data are maintained and continued. Collection of new data sets should be initiated.
- A data system that provides easy, integrated, and complete access to past, present. and future data must be developed as soon as possible.
- A long-term research effort must be sustained to study and understand these time series of earth observations.
- The EOS program should establish an information system to cany out those aspects of the recommendations that go beyond existing and planned activities.
- The scientific direction of EOS should be established and continued through an International Scientific Steering Committee.

The Earth System Sciences Advisory Committee (ESSAC) was appointed in November 1983 by the NASA Advisory Council to consider directions for NASA's Earth Sciences program. The committee's report, issued in May 1986, recognized EOS as the centerpiece of the future Earth Sciences implementation strategy. It stated the following goal of earth system science: "To obtain a scientific understanding of the entire earth system on a global scale by describing how its component parts and their interactions have evolved, how they function, and how they may be expected to continue to evolve on all time scales." It also identified the following challenge to earth system science: "To develop the capability to predict those changes that will occur in the next decade to century, both naturally and in response to human activity."

The successor to the SMRWG, the EOS Science Steering Committee (SSC), continued the definition of the EOS program and provided an overall implementation strategy in its report issued in 1987. Concurrent with the SSC work, NASA included the EOS program under a broader Agency initiative termed Mission to Planet Earth, which included other efforts such as the earth probe missions and NASA's participation in the International Geosphere Biosphere Program (IGBP) and the World Climate Research Program (WCRP). By proceeding to carry out the recommendations of the SMRWG and the ESSAC, including EOS, the SSC argued that it would be possible to move from a single-discipline research mission to a comprehensive mission addressing all aspects of the earth as a system. Thus, the concept of an earth system was adopted as the EOS scientific thrust.

An Announcement of Opportunity (AO) to solicit proposals for EOS investigations was issued in January 1988. The EOS program objectives were based on the requirements and goals of the SMRWG, SSC, and ESSAC. In responding to the AO, proposers could offer to do interdisciplinary studies to carry out integrated earth system research leading to the development of comprehensive earth system models, to be members of research facility teams (formed to provide scientific guidance for the development of the research Facility Instruments (FI) and to analyze and interpret data from them), or to be Principal Investigators (PI) of proposed instruments and data products. The EOS selection process was completed in February 1989, with the selection of six team leaders and 93 team members for the six NASA research FI's, 24 instrument PI's, and 29 interdisciplinary team PI leaders to participate in the definition phase of the EOS program.

The EOS Investigators Working Group (IWG), formed in 1989, consists of PI's (instrument and interdisciplinary), and team leaders to provide scientific advice and guidance for the program. The program scientist (from NASA Headquarters) and the senior project scientist (from GSFC) co-chair the IWG. The working bodies of the IWG include twelve science panels. The chairpersons of each of these panels, together with the program scientist and senior project scientist, constitute the Science Executive Committee (SEC) of the IWG. Membership on the panels is generally open to all EOS investigators, including co-investigators on any EOS investigation and members of EOS FI teams. Scientists outside the group of EOS investigators are also included in the various panels.

The IWG plays a leading role in defining the overall science thrust for the EOS program. It coordinates the research efforts and provides guidance and advice to the EOS program and project, as appropriate, concerning all major scientific issues. It will meet regularly throughout the lifetime of the program.

The EOS study project was established at GSFC in 1983. During the Phase A and B study periods, GSFC and the Jet Propulsion Laboratory (JPL) performed mission, data system and spacecraft studies resulting in a conceptual design of a dual series of spacecraft missions that would satisfy the EOS requirenients. The spacecraft were designated EOS-A and EOS-B, with GSFC and JPL having the respective managerial responsibilities. Following the EOS Non-Advocacy Review (NAR), held in June 1989, management responsibilities for the EOS-B series, as well as the project management role for the execution phase of EOS, were transitioned to GSFC. The Synthetic Aperture Radar (SAR), which was a flight instrument to be launched on EOS-B, was identified as an independent mission, to be managed by JPL, and a candidate for separate program approval. In 1990, responsibility for development of the platform was transferred from the space station program to EOS. EOS management became centralized within the EOS project at GSFC.

The EOS program was approved by Congress as an FY 1991 budget initiative. The payload for the first flight (EOS-A1) was selected in January 1991, following conceptual design and cost reviews of the selected instruments and IWG Payload Panel recommendations on scientific priorities and synergism, The baseline flight segment consisted of two series of large observatories, EOS-A and-B, in 1:30 PM ascending, sun-synchronous orbit, launched by a Titan-IV with solid rocket motor upgrades from the Western Space and Missile Center (WSMC). Each observatory had a five-year life and each was to be replaced twice to provide a 15-year mission. The budget runout through FY 2000 was $17 billion.

The NRC advises the federal government through reports of reviews it conducts using its various committees, which involve the broad community of science and technology experts. Prior to the EOS new start approval in FY 1991, their report, "The U. S. Global Change Research Program: An Assessment of FY 1991 Plans," provided a critical review of the EOS program.

In the July 1991, report, "Assessment of Satellite Earth Observation Programs 1991," the NRC was in general agreement with the EOS plan for the large EOS-A observatory and its selected payloads. It expressed concern that the total EOS budget size could lead to potential delays, noted data gaps in key areas, and endorsed the earth probe concept. These reviews were the beginning of a series of evaluations of the program to ensure the proper scientific return on the EOS investment.

As part of the FY 1992 budget process, the Committees on Appropriations directed NASA to restructure the EOS program to:

- Focus the science objectives of EOS on the most important problem of global change (i.e., global climate change).
- Increase the resilience and flexibility of EOS by flying the instruments on multiple, smaller platforms rather than a series of large platforms.
- Reduce the cost of EOS through FY 2000 to $1 1 billion.

In the summer and fall of 1991, NASA conducted a restructuring of the program to meet the Congressional mandate. This process included an independent review by the External Engineering Review Committee, which issued its report in September 1991. The process also involved assessment by the scientists who will use the data from EOS, including both the EOS IWG and the EOS Payload Advisory Panel. The EOS project at GSFC conducted studies to determine how the EOS instruments could most effectively be configured on small spacecraft. In December 1991, the NASA Administrator reviewed and approved the restructured EOS program, and in March 1992, NASA submitted its report on the restructured program to Congress. Congress approved the restructured program in 1992.

Recognizing that the subsequent budget environment would not support the complete and timely implementation of the restructured EOS program described in the March 1992, report to Congress, the NASA Administrator directed that the program be rescoped with a goal of further reducing its costs through FY 2000 by 30% to $8 billion. The EOS rescope was completed in June 1992, satisfying the 30% reduction by capitalizing on efficiencies, reducing at-launch science data products, by rephasing work, by increasing international participation, and by deleting the High-Resolution Imaging Spectrometer (HIRIS) flight instrument. As a result of the rescoping process, EOS became recognized by NASA as a cost-driven program.

In the 1995 Congressional budget cycle, the EOS budget was reduced by $758.5 million through FY 2000, to $7,243.4 million, of which $131.3 million was due to a funding responsibility transfer. The EOS rebaselining effort conducted in 1994, with the following results, was reflected in the FY 1996 budget submission.

- Preserve the scientific integrity of EOS and Earth Science
- Preserve the measurement complement of the first mission in each series
- Preserve the launch dates for AM-1, PM-1 and Chemistry-1
- Phase EOSDIS development to support missions through FY 2000
- Restore reserves to a prudent level
- Incorporate appropriate technology advancements
- Fit within annual funding guidelines for the EOS program
- Replace major spacecraft at six year intervals

Public Law 102-555 returned the development, operations and data distribution of the Landsat-7 program to the federal government in 1992. It established the Landsat Program Management (LPM) team comprised of the DoD and NASA. DoD was responsible for the acquisition of the satellite and NASA was responsible for the development of the ground system. In the fall of 1993, DoD withdrew from the program. At the direction of the National Science and Technology Council (NSTC), the Office of Science and Technology (OSTP) initiated a review and restructuring of the Landsat-7 program. Under Presidential Decision Directive (PDD)/NSTC-3, the Land Remote Sensing Strategy was established. This strategy implemented a program management structure for the Landsat-7 program, which made NASA responsible for development of the satellite, instrument and ground system, NOAA responsible for operations, and the USGS, in conjunction with the EOSDIS Land Process Distributed Active Archive Center (LPDAAC), responsible for data archive and distribution.

During the EOS rebaselining process, the Landsat-7 program was integrated with EOS. As another aspect of the rebaselining, the EOS science program was reorganized. The funding to support the activities of the EOS instrument investigators and interdisciplinary science investigators was moved to research and analysis. The science algorithm development and maintenance remains in the EOS budget.

During 1995, NASA conducted a comprehensive review of EOS to reshape mission planning to accomplish a number of interrelated objectives: substantially reduce EOS life-cycle costs while preserving the basic measurement set: provide now for technology infusion so that it will be available in time to be able to lower the cost of the second and third EOS series; provide new science opportunities through small satellites; and, adjust program management to an evolutionary approach.

This "reshaping" exercise recognized that the first series already employs or advances the state-of-the-art in spacecraft and instruments. Even so, savings achieved in the EOS Data Information System (EOSDIS) implementation and other changes enable some savings and iniprovements in the first series. These include accelerating Laser Altimetry and Active Cavity Radiometer

Irradiance Monitor (ACRIM), by one year, providing a spacecraft for SOLSTICE (previously awaiting a flight of opportunity), and the explicit provision of funding within the EOS budget for new technology missions.

The 1997 Biennial Review completed the shift in planning for future missions (i.e., beyond the EOS first series) that began in the 1995 "reshaping" exercise. Emerging science questions drive measurement requirements, which drive technology investments in advance of instrument selection and mission design. Mission design includes such options as purchase of science data from commercial systems and partnerships with other Federal agencies and international agencies. The result is a more flexible and less expensive approach to acquiring Earth Science data.

AM-1

A new generation of Earth Science will begin with the successful launch and checkout in 1998 of EOS AM-1 - one that studies the earth as a global system. Because the AM-1 spacecraft primarily observes terrestrial features, a morning equatorial crossing time is preferred to minimize cloud cover over land. EOS AM-1 will carry a complement of five synergistic instruments. The Clouds and Earth's Radiant Energy System (CERES) instrument will perforni measurements of the earth's "radiation budget" or the process by which the earth's climate system maintains a balance between the energy that reaches the earth from the sun, and the energy that radiates from earth back into space. The components of the earth system that are important to the radiation budget are the planet's surface, atmosphere, and clouds. The Multi-angle Imaging Spectroradiometer (MISR) will measure the variation of the surface and cloud properties with the view angle. Meanwhile, the Moderate-Resolution Imaging Spectroradionieter (MODIS) will measure atmosphere. land, and ocean temperature, and moisture profiles, snow cover and ocean currents. The Canadian Measurements of Pollution of the Troposphere (MOPITT) instrument is an infrared gas-correlation radiometer that will take global measurements of carbon monoxide and methane in the troposphere. The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), provided by Japan, will measure cloud properties, vegetation index, surface mineralogy, soil properties, surface temperature and obtain digital elevation modes. The primary contractors associated with the program are Lockheed Martin Missiles and Space (LMMS) for the AM-1 spacecraft, Hughes Santa Barbara Remote Sensing (SBRS) for the MODIS instrument, TRW for the CERES instrument (the instrument has also been flown on the TRMM in 1997 and will fly on the PM spacecraft), and Lockheed Martin Commercial Launch Services for the AM-1 Atlas Centaur/IIAS launch service.

PM-1

The research focus of the PM-1 spacecraft is atmospheric temperatures and humidity profiles, clouds, precipitation, arid radiative balance: terrestrial snow and sea ice: sea-surface temperature and ocean productivity; soil moisture; and the improvement of numerical weather prediction. With the emphasis of the instrument complement being cloud formation, precipitation, and radiative properties, an afternoon equatorial crossing is more suitable for acquiring the data. The primary contractors associated with the program are TRW for the common spacecraft to be used for PM-1; Lockheed Martin Infrared and Imaging Systems (LMIRIS) and JPL for the Advanced Infrared Sounder (AIRS) instrument: and Aerojet for the Advanced Microwave Sounding Unit (AMSU) instrument. Japan will provide the AMSR instrunient for the PM-1 spacecraft and Brazil will provide a microwave instrument, the HSB. The launch of PM-1 is scheduled for December 2000.

Chemistry-1

The study area for the Chemistry-1 will be atmospheric chemical species and their transformations. The Tropospheric Emission Spectrometer (TES) and the Microwave Limb Sounder (MLS) instruments are planned to be built in-house at JPL. TRW is the contractor for the Chemistry—1 common spacecraft to be used also for PM-1 The University of Colorado and Rutherford Appleton Lab/Oxford University in the United Kingdom will provide the High Resolution Dynamics Limb Sounder (HIRDLS) instrument for the Chemistry-1 spacecraft. Preliminary discussions are currently under way with the Dutch for a possible ozone measuring instrument. The launch of Chemistry-1 is scheduled for December 2002.

Special Spacecraft

The special spacecraft will be designed to study atmospheric aerosols, ocean circulation, ice-sheet mass balance, cloud physics, atmospheric radiation properties, and solar irradiance. Ball Aerospace is responsible for developing the Stratospheric Gas and Aerosol Experiment (SAGE III) that will fly on a Russian spacecraft in 1999 and a flight of opportunity planned for a 2000 launch. The SAGE III will take advantage of both solar and lunar occultation to measure aerosol and gaseous constituents of the atmosphere. The Japanese will provide the Advanced Earth Observing System II (ADEOS II) spacecraft for the Seawinds instrument to measure ocean surface wind velocity as a follow-on to the NASA Scatterometer instrument on ADEOS-I and the Seawinds instrument on QuikScat. The first Radar Altimetry mission, Jason-1, will be a follow-on to the TOPEX/Poseidon as a joint mission with the French Space Agency (CNES), with data provided to NOAA for operational purposes. The Laser Altimetry mission is presently planned as a dedicated domestic mission. The ACRIM, will continue the measurement of Total Solar Irradiance (TSI) begun by the ACRIM instruments on the Solar Maximum Mission and UARS. The Total Solar Irradiance Mission (TSIM), a new mission to measure total solar irradiance, will be launched as part of the joint SciSat Program with the Canadian Space Agency (CSA).

Landsat

With the launch of Landsat-7 in 1998, substantially cloud-free, sun-lit land surface imagery for detecting and characterizing regional and global change will continue. The primary contractors are Lockheed Martin Missiles and Space (LMMS) for the Landsat-7 spacecraft, SBRS for the Enhanced Thematic Mapper Plus (ETM+), and Boeing for the Landsat-7 Delta II launch service. The Landsat-7 estimate includes funding for ground segment development. NOAA will be responsible for operating the satellite and the USGS will archive the data.

Technology Infusion

The New Millennium Program (NMP) budget reflects a commitment to develop new technology to meet the scientific needs of the next few decades and to reduce future EOS costs through focused technology demonstrations for earth orbiting missions. Two Headquarters enterprises are coordinating their program plans to do these missions. Earth Science has joined the Office of Space Science in the New Millennium Program in order to capitalize on common work from core technology development programs and specific spacecraft and instrument studies. The prograni will identify and demonstrate advanced technologies that reduce cost or improve performance of all aspects of missions for the next century, (i.e., spacecraft, instruments and operations). The program objectives are to spawn "leap ahead" technology by applying the best capabilities available from several sources within the governnient, private industries and universities. These low-cost, tightly controlled developments, the Earth Observers (EO), will take more risk in order to demonstrate the needed technology breakthroughs and thus reduce the risk of using that technology in future science missions. Missions will be selected based on their ability to meet the science needs of the future by innovative technology that would also decrease the cost and improve the overall efficiency of space flight missions.

Increased technology work will be pursued in the areas of sensor and detector systems. Emphasis is being placed on developing new capabilities for Earth Science sensors and integrated, autonomous, self-calibrating instruments. Studies are being conducted in the areas of differential absorption Light Direction and Ranging (LIDAR) and OH (hydroxyl) radiometer.

The instrument incubator initiative is expected to reduce the cost and development time of future scientific instruments for Earth Science. The instrument incubator program will aggressively pursue emerging technologies and proactively close the technology transfer gaps that exist in the instrument development process. The program will take detectors and other instrument components coming from NASA's fundamental technology development programs, and other sources, and focus on combining them into new instrument systems which are smaller, less costly, less resource intensive, and which can be developed into flight models more quickly for future Earth Science missions. This includes the key follow-on instruments for the EOS.

EOS Follow-On

The next generation of EOS missions will provide new technology and space systems to meet the scientific needs for the NASA Earth Science programs. Systematic and process measurements will be defined to support the five science theme areas. New instrument technologies will be tested, validated, and made available to support science proposals for selection of measurements, principal investigators. and instruments for the next EOS missions. All EOS measurements, principal investigators, and instruments will be selected as a result of a broad agency announcement that will include peer review, with the goal of a first planned follow on launch for FY 2004. Launches are expected each year through 2009.

MEASURES OF PERFORMANCE

Preliminary Design Reviews - Confirms that the proposed project baseline is comprehensive (meets all program level performance requirements), systematic (all subsystem/component allocations are optimally distributed across the system), efficient (all components relate to a parent requirement), and represent acceptable risk.

Earth Observer-1
Plan: February 1997
Actual: February 1997

PM-1
Plan: April 1997
Actual: April 1997

ACRIM
Plan: March 1998

Earth Observer-2
Plan: June 1998

Chemistry-1 Plan: March 1998 Revised: March 1999	Rescheduled to accommodate revised budget first reported in the 1998 budget

TSIM
Plan: March 1999

Critical Design Reviews - Confirms that the project system, subsystem, and component designs, derived from the preliminary design, is of sufficient detail to allow for orderly hardware and software manufacturing, integration and testing, and represents acceptable risk. Successful completion of the critical design review freezes the design prior to actual development.

Earth Observer-1 Plan: April 1997 Actual: June 1997	Schedule changed to accommodate a grating spectrometer, which was recently added to the mission
PM-1 Plan: April 1998 Revised: June 1998	Revised schedule due to late start following resolution of protest first reported in the 1998 budget
Earth Observer-2 Plan: January 1999	
Chemistry-1 Plan: June 1999 Revised: April 2000	Revised instrument schedule to accommodate revised budget first reported in the 1998 budget

Instruments Delivered - Confirms that the fabrication, integration, certification, and testing of all system hardware and software conforms with their requirements and is ready for recurring operation. Throughout system development, testing procedures or, as appropriate, engineering analysis have been employed at every level of system synthesis in order to assure that the fabricated systeni components will meet their requirements.

Landsat-7 Plan: December 1996 Revised: December 1997	Delays due to technical problems (power supply, panchromatic band noise, mirror scan) and inefficiencies at Santa Barbara Remote Sensing
AM-1 last instrument Plan: February 1997 Revised: August 1997	Test anomalies occurred on the MOPITT instrument; which required rework by Canadians.
SAGE-I11 (Russian) Plan: December 1997 Revised: February 1998	Due to instrument detector problems
Seawinds Plan: March 1998	Under review.
Earth Observer-1 Plan: October 1998 Revised: December 1998	Schedule changed to accommodate a grating spectrometer, which was recently added to the mission, first reported in the 1998 budget
PM-1 last instrument Plan: December 1998 Revised: September 1999	lnstrument deliveries delayed, first reported in the 1998 budget
Earth Observer-2 Plan: August 2000	
Laser Altimeter Plan: October 2000	
Chemistry-1 last instrument Plan: June 2001 Revised: March 2002	Slower than expected start-up due to configuration studies.

QuikScat
Plan: May 1998

ACRIM
Plan: October 1998

Jason-1
Plan: March 1999

Laser Altimetry
Plan: October 2000

TSIM
Plan: March 2001

Algorithm Development (Version 2) - Confirms that the second version of the science software necessary for the production of the standard data products for each mission has been developed and is ready to support launch.

AM-1
Plan: February 1998

Aerosol SAGE-III (Russian) Plan: December 1997 Revised: March 1998	Added time needed to complete algorithm development, first reported in the 1998 budget
Jason-1 Plan: December 1998 Revised: October 1999	Revised due to delayed selection of science team and revised launch date.

Earth Observer-1
Plan: April 1999

PM-1
Plan: July 2000

Chemistry-1
Plan: December 2001

Laser Altimetry-1 Plan: July 2002 Revised: October 2000	Revised to accommodate acceleration made possible by catalog spacecraft development approach.

Launch Readiness Dates - Verifies that the system elements constructed for use, and the existing support elements, such as launch site, space vehicle and booster, are ready for launch.

AM-1 Plan: June 1998	
QuikScat Plan: November 1998	
Landsat-7 Plan: December 1998	
ACRIM Plan: October 1999	
Aerosol SAGE-111 (Russian) Plan: December 1998 Revised: July 1999	Revised to increase mission reliability by enhancing the testing of critical subsystems for the newly developed METEOR spacecraft
Earth Observer-1 Plan: 1998 Revised: May 1999	Schedule changed to accommodate a grating spectrometer, which was added to the mission, first reported in the 1998 budget
Seawinds Plan: August 1999 Revised: 2000	Launch date of Seawinds on ADEOS-II is under review.
Jason 1 Plan: December 1999 Revised: May 2000	Delayed to accommodate spacecraft development by French space agency (CNES) partner
PM-1 Plan: December 2000	

Earth Observer-2
Plan: January 2001

Chemistry-1
Plan: December 2002

Laser Altimetry-1
Plan: July 2002
Revised: July 2001

Due to new catalog spacecraft approach, the launch was accelerated.

TSIM
Plan: December 2001

SOLSTICE
Plan: December 2002

ACCOMPLISHMENTS AND PLANS

AM Spacecraft

Fabrication and assembly of all AM-1 spacecraft subsystems were completed in FY 1997. Fabrication and assembly of all AM-1 instruments (ASTER, CERES, MISR, MODIS, and MOPITT), and integration and test of the instruments was completed in FY 1997 All AM-1 instruments have been delivered to Lockheed Martin for integration onto the spacecraft.

Integration arid test of the integrated AM-1 spacecraft was completed in the first quarter FY 1998. Version 1 of the science software was delivered in the second quarter of FY 1997. The second external independent readiness review was held prior to the start of environmental testing of AM-1 (with all instruments integrated onto the spacecraft). Environmental testing began in December 1997.

The spacecraft will be delivered to the Astrotech commercial launch processing facility at the Vandenberg AFB. California, where system end-to-end testing will be performed and preparation for launch will be completed. Launch is scheduled for June 1998.

PM Spacecraft

Phase B of the PM-1 spacecraft contract has been completed, including a Spacecraft Configuration Audit (SCA), Bus Requirements Review (BRR), and the Preliminary Design Review (PDR). The spacecraft is now in the design phase which will be concluded with the successful completion of the Critical Design Review (CDR) in June 1998. CERES flight models 3 and 4, and MODIS flight model 1 are proceeding satisfactorily. The Brazilian Space Agency has signed a joint Memorandum of Understanding (MOU) with NASA to provide the HSB for the PM-1 platform. This instrument has a significant heritage to the Advanced Microwave Sounding Unit-B (AMSU-B), which is being developed for the U. S. meteorological satellites. Japan (NASDA) has agreed lo provide the AMSR; it was recognized as an "official project" by NASDA in June 1997. This instrument is a replacement for the Multi-frequency Imaging Microwave Radiometer (MIMR) instrument which ESA was to provide but withdrew. Phase C development of AMSR is on schedule and proceeding satisfactorily.

The PM-1 spacecraft PDR was held in April 1997. Fabrication and assembly of the AIRS engineering model will continue with delivery in and start of performance verification testing in December 1997. AMSU, CERES and MODIS will be in various stages of fabrication, test and integration. The AMSR CDR will be completed in mid-1998. The HSB instrument design review was held in June 1997.

The PM-1 spacecraft CDR will be held in June 1998. The AIRS, AMSU, CERES and MODIS will complete fabrication, test and assembly and will be delivered in 1998. HSB and AMSR will be delivered by September 1999. The EOS common spacecraft design will be completed and fabrication of the PM-1 flight subsystems will begin in FY 1998.

Chemistry Spacecraft

The Chemistry-1 mission, focusing on the impact of greenhouse gases on global climate has been maturing in terms of instruments design concepts. The HIRDLS, MLS, and TES have initiated Phase C/D development. HIRDLS completed PDR in FY 1997. The Japanese have decided riot to provide the Ozone Dynamics Ultraviolet Spectrometer (ODUS) due to their budgetary reasons. Preliminary discussions have been held with the Dutch on their possible provision of an Ozone Monitoring Instrument (OMI) as a replacement for the ODUS instrument. TRW was given the authorization to proceed (ATP) for the second copy of the common spacecraft as the Chemistry-1 instrument platform.

In 1999 TES and HIRDLS CDRs will be completed including the engineering model. HIRDLS will be in the fabrication phase. The OMI will be in the design phase with culmination of the PDR.

Special Spacecraft

The Jason-1 MOU between the United States and France was signed in January 1997. France will provide the spacecraft, solid-state altimeter, and Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) positioning system, NASA will provide the microwave radiometer, global positioning system and laser retroreflector array. The ground system and mission operations will be shared. NASA will also provide the launch services. Delays in the CNES satellite development program and altimeter development have rescheduled the launch of Jason-1 to May 2000. NASA supported a Jason-1 PDR in June 1997 and initiated the Boeing Della II launch vehicle contract in September 1997. NASA instrument progress was ahead of schedule, with the Jason Microwave Radiometer engineering model component delivered.

The Jason-1 activities for 1998 will focus on the completion of the critical design for all flight elements. Engineering model developnient and test is under way or complete for the technologically difficult instruments, the altimeter and Jason Microwave

Radiometer. The CDRs for these instruments are both scheduled early in 1998 to support a system-level CDR for the satellite in June 1998. Flight models of the instruments will be built during the second half of 1998 for delivery to the payload integration activity at CNES next year. Another critical activity under way in 1998 is the design and development of the Dual Payload Attach Fitting (DPAF) an addition to the launch vehicle structure that would accommodate the dual Jason-1/TIMED payload on the Delta II launch vehicle.

The critical 1999 Jason-1 activities are the integration and test of the instruments into **an** instrument package, then the integration and test of the satellite bus and instrument payload. These tests will include the environmental tests, and important milestone. Another critical milestone will be the test readiness review in 1999 for the ground system to operate Jason-1 and process the returned data.

In early 1997 the Laser Altimetry Mission (LAM) completed a cooperative industry study on the suitability of catalog spacecraft for the Geoscience Laser Altimeter System (GLAS), a new technology instrument with critical positioning requirements for the cryosphere mission. Formally known as an Indefinite Delivery/Indefinite Quantity (IDIQ) rapid delivery spacecraft contract, a "catalog" spacecraft procurement is one in which commercial spacecraft and options (for data rates, pointing accuracies, etc) are pre-qualified and priced. Once in place, program managers and scientists can pick the optimal spacecraft and options for their mission. Results indicated that not only would the catalog spacecraft approach work for LAM, such an approach would allow the mission to be ready for launch earlier at a reduced cost. The Earth Science Biennial Review validated the new approach and the LAM launch readiness date was accelerated to July 2001. The GLAS instrument completed a system requirements review in May 1997 and initiated procurement of various engineering model components.

The LAM team assisted in the rapid spacecraft procurement activity and is currently selecting the most suitable catalog spacecraft for the GLAS instrument. The GLAS PDR is scheduled for the second quarter of 1998 to be followed by a confirmation review by an independent team of the overall mission. The launch vehicle for LAM will be selected to support a Mission Design Review in late 1998. Components for the engineering model of the instrument will be delivered and integrated for testing in 1999.

The critical activities for LAM in 1999 will be flight hardware fabrication, The GLAS engineering model will be tested and delivered to the spacecraft and fabrication of the flight model will begin. The spacecraft flight hardware will be built and integrated for environmental testing the following year. The beta version of the LAM algorithms will be delivered to EOSDIS for testing of the data product generation.

Phase B activities for the SOLSTICE instrument continue on schedule with the goal of supporting a flight opportunity in 2002. There are two Stratospheric Gas and Aerosol Experiment (SAGE version III) instruments to be manufactured and flown to provide for the long-term monitoring of ozone and aerosol, The instrument is in the final phase of test and development. The first SAGE mission will fly on a Russian Meteor-3M spacecraft in July 1999. The second mission is a Flight of Opportunity (FOO), planned for an early turn of the century launch once an affordable opportunity is identified. The logistics, testing, integration, and launch plans are in place with the Russians for the Meteor-3M spacecraft for the first mission. The two SAGE instruments will be delivered in 1998.

The Seawinds CDR was completed in January 1996. The Seawinds instrument will continue to undergo protoflight model fabrication and assembly during FY 1998. The Seawinds instrument activities will consist of integration and test of the instrument. The protoflight model is scheduled for delivery to Tsukuba, Japan in late 1998 for a 2000 launch on the ADEOS II spacecraft by a NASDA H-II rocket from Tanegashima, Japan.

The ACRIM instrument started Phase C/D development in early 1997. A contract was awarded to Orbital Sciences Corporation in July 1997 for a small spacecraft and ground station. The launch readiness date has been changed to October 1999 because of delays in getting a spacecraft vendor and previous Pegasus XL launch failures. ACRIMSAT will be launched as a dual payload on a Pegasus XL.

NASA issued an announcement of opportunity for the TSIM in August 1997. Selection is planned for early 1998 for a launch in December 2001. TSIM will be NASA's science contribution to the joint SciSat program with the CSA.

QuikScat

The QuikScat mission will fill the ocean-wind vector data gap created by the loss of the NASA Scatteronieter (NSCAT) on the Japanese Advanced Earth Observing Satellite (ADEOS-I) spacecraft. The NSCAT instrument ceased to function when ADEOS-I failed on June 30, 1997. The follow-on Scatterometer, Seawinds, is scheduled for launch on the Japanese ADEOS-II spacecraft in 2000. Spares from the Seawinds instrument will be used to assemble the QuikScat Scatterometer instrument. Ball Aerospace Systems Division of Boulder, Colorado was selected on November 19, 1997, to provide the QuikScat spacecraft. Ball was selected via the IDIQ rapid delivery spacecraft contract. QuikScat is planned for launch on a Titan-II from Vandenberg Air Force Base in late 1998.

Landsat

The Landsat-7 ETM+ instrument was delivered in December 1997. Spacecraft integration and testing continues. Testing will be completed in early 1998. End-to-end test of the spacecraft and ground system will occur in May 1998.

The spacecraft will be delivered to California Space Port commercial launch processing facility at the Vandenberg AFB where systems end-to-end testing will be performed and preparation for launch will be completed. Launch is planned in 1998. The Landsat-7 operations will transition to NOAA 90 days after launch.

Technology Infusion

The New Millennium Program (NMP) focuses on identifying and demonstrating, in flight, advanced technologies that reduce cost or improve performance of spacecraft and instruments. The NMP emphasizes partnering with industry, academia and other Government agencies. The missions are selected on an annual basis. The Earth Observer (EO-1) Advanced Land Imager is the first mission selected under the NMP series and is scheduled for launch in 1999. The EO-1 consists of an Advanced Land Imager (ALI) instrument, a spacecraft, and numerous advanced technologies as an integral part of the mission. The EO-1 is in Phase C/D and has completed CDR. In 1998 the EO-1 mission will complete instrument and spacecraft fabrication and will commence the test and integration phase. In 1999 the EO-1 mission will be launched.

The Space-Readiness Coherent Lidar Experiment (Sparcle)was officially selected as an EO-2 mission in November 1997. The Sparcle mission is due to launch in 2001. The mission will fly an infrared laser in the cargo bay of the Space Shuttle to determine if a space-based sensor can accurately measure global winds within earth's atmosphere from just above the surface to a height of about 10 miles. The measurement in this region of the atmosphere may lead to improved weather forecasting and a better understanding of climate-related events such as El Nino .

During FY 1997 and FY 1998, specific tests and demonstrations will take place in the sensor and detector technologies as we attempt to reduce systems by at least an order of magnitude in mass, power, and volume from the existing differential absorption LIDAR. Work will continue in the development of ultra-stable, solid slate laser local oscillators for atmospheric and astronomical spectrometers suitable for measurements of atmospheric hydroxyl.

EOS Follow On

EOS follow-on missions will begin science instrument definition and design. A science workshop will be held in the spring of 1998 and an announcement of opportunity will kick off the start of the follow-on missions. Funding will be used for multiple phase A arid B studies of candidate instruments for the early follow-on missions. Funds will be used to carry selected installments through detailed design and engineering model development. In FY 1998, fabrication of CERES flight model 5 will continue to meet systematic measurements requirements for earth radiation budget measurements in the near term. Definition for the detailed design of the Integrated Multispectral Atmospheric Sounder (IMAS) instrument, a high accuracy temperature and humidity sounder, will be conducted as a candidate for flight on NOAA N'. In FY 1999, initial studies for the advanced global imager and the high resolution land imager will be initiated.

BASIS OF FY 1999 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM DATA INFORMATION SYSTEM

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Earth Observing System Data Information System...........	234,600	209,900	256,600

PROGRAM GOALS

The goals for the EOS Data Information System (EOSDIS) are the development and operation of a highly integrated system which can: (1) operate the EOS satellites; (2) acquire instrument data; (3) produce data and information products from the EOS, to preserve these and all other Earth Science environmental observations for continuing use; and (4) make all these data and information easily available for use by the research, education, government agencies and all those who can benefit from them in making economic and policy decisions. The EOSDIS facilitates the goals of Earth Science by enabling the public to benefit fully from increased understanding and observations of the environment.

STRATEGY FOR ACHIEVING GOALS

The EOSDIS is based on an evolutionary design to develop capabilities with the phased deployment of the EOS satellites and to enable adaptation to changes in user needs and technology. The design is also modular, allowing the replacement of individual components without costly, overall system changes or disruptions in service. NASA is making extensive use of prototypes to assure that EOSDIS will effectively meet the needs of the satellites and users. A limited amount of technology development and adaptation is focused specifically on meeting EOSDIS evolutionary needs while relying on other programs at NASA and other agencies to fund technology development efforts of a more generic nature, i.e., communications technology. An initial version of the system, Version 0, implemented at eight Distributed Active Archive Centers (DAACs) and through cooperative efforts with NOAA, the USGS, and international partner space agencies, became operational in 1994.

Plans for development of subsequent versions of the EOSDIS system have been redrawn. Unique developmental activity in Version 1, Release A, in support of the first flight of two EOS instruments on TRMM in 1997, has been redirected from the EOSDIS Core System (ECS) contractor to the GSFC and LaRC DAAC contractors. The remaining developmental effort previously in Release A and performed by the ECS contractor, has been folded into Version 2.0 in support of Landsat-7 and AM-1 in 1998, still to be performed by the ECS contractor.

The EOSDIS development has been divided into four major components: the EOS Data and Operations System (EDOS) which has been developed by TRW, the EOSDIS Backbone Network (EBNET) which has been developed in-house by GSFC with Computer Sciences Corporation and Allied-Signal, the ECS which is under development by Hughes Information Technology Systems, and the DAACs. The EDOS receives the raw data stream from the satellites, separates the data by instrument, and performs the initial processing and back-up archiving. The EBNET delivers the real-time data to and from the operations control centers and the science data to the DAACs described below. The ECS includes the flight operations segment which provides satellite and instrument command and control; the communications and systems management segment which provides data product generation, archival, and distribution; and the science data processing segment, which provides the systems to integrate all EOSDIS user functions. The DAACs currently have a limited operational capability using EOSDIS Version 0. The EOSDIS Independent Verification and Validation (IV&V) contract is with Internietrics Systems Services Corporation.

The EOS Data and Operations System (EDOS) element of the EOSDIS has been replanned in an effort to reduce cost and improve efficiency. Trade-off studies between the Space Network and ground stations for EOS data acquisition were performed. These studies resulted in changes to the architecture of EDOS, with some minor architectural implications on other elements of EOSDIS. The previous baseline architecture was to perform Level 0 data processing at the White Sands Complex (WSC). The processed data would then be distributed from WSC to the DAACs. The assumption for that architecture was that all EOS missions would be supported via the Space Network. The current architecture calls for missions beyond ***AM-*** 1 to be supported by EOS ground stations (being built in Alaska and Norway) instead of the Space Network. The ***AM-*** 1 mission can use either Space Network or ground stations. Under this new architecture, Level 0 processing will be performed at GSFC and the processed data will be distributed to the DAACs. This architecture saves money in hardware development costs for EOS spacecraft, reduces risk to PM- 1 development, saves money in data transport costs, streamlines data flow, and allows for the potential commercialization of data acquisition.

Using the ECS, the eight DAACs will process the raw data from the satellites into useful products, handle all user product searches, requests, orders, and distribute data and inforniation directly to the user community primarily via the national information infrastructure. The DAACs also permanently archive all Earth Science data and inforniation for future use. To serve the user community, each DAAC focuses on the data needs of a specific segment of the user community. Any user may access the entire Earth Science data holdings from any DAAC via the Internet/World Wide Web as well as gaining access to affiliated systems at other agencies nationally and internationally. Each DAAC is guided by a user working group. In response to recommendations by the NRC Board on Sustainable Development, NASA is currently evaluating alternative concepts to perform the DAAC functions.

The eight DAACs are:

- Alaska Synthetic Aperture Radar (SAR) Facility, University of Alaska Geophysical Institute, Fairbanks, Alaska
- Earth Resources Observation System (EROS) Data Center, U. S. Geological Survey, Sioux Falls, South Dakota
- Goddard Space Flight Center, Greenbelt, Maryland
- Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California
- Langley Research Center, Hampton, Virginia
- National Snow and Ice Data Center, University of Colorado, Boulder, Colorado
- *Oak* Ridge National Laboratory, U. S. Department of Energy, Oak Ridge, Tennessee
- Socio-Economic Data and Application Center (SEDAC), Saginaw. Michigan

Currently, EOSDIS Version 0 allows direct access to selected pathfinder data holdings from the USGS and NOAA. Relationships with Canada, Japan, Russia, Israel, Australia and several European countries have been established for the exchange of data for EOSDIS. Many multi-agency efforts, in addition to the NASA EOSDIS, are working to improve environmental data availability to the public. especially in the Interagency Working Group on Data Management for Global Change and the Federal Geographic Data Committee.

MEASURES OF PERFORMANCE

EOSDIS Version 1 Plan: January 1997	Support the archival and management of data from the two EOS instruments on TRMM. The ECS contractor failed the initial lest readiness review of Version 1, Release A. NASA issued a stop work order for developing software unique lo supporting the two EOS instruments on TRMM. This work will now be performed by contractors at the GSFC and LaRC DAACs funded by EOSDIS.
EOSDIS Version 2 Plan: October 1997 Operational V. 2.0 Plan: May 1998 Revised: June 1998 V. 2.1 Plan: January 1999 Revised: November 1998 V.2.2 Plan: April 1999	Support the launch of AM-1 and Landsat-7. Version 2 will be broken into incremental deliveries, Version 2.0 will provide all mission essential functions to support AM-1 and Landsat-7 launches. Version 2.1 will provide additional functions needed for long-term data operations to support AM-1 and Landsat-7. Version 2.2 will provide additional AM-1 and Landsat-7 support functions as operational enhancements. Technical difficulties with software development for ECS.
EOSDIS Version 3 Plan: December 1999 Revised: January 2000	Support the launch of the PM-1 mission, first reported in the 1998 budget

Providing broad and efficient access to data products is key to meeting the Agency mission of advancing and communicating scientific knowledge. The successful functioning of EOSDIS is essential to the accomplishment of all three of Earth Science's strategic goals. Three key indicators of DAAC perfomiance are the volume of data archived (projected in FY 1998 to be approximately 250 terabytes), the number of users accessing the DAACs (almost 800,000 web hits projected in FY 1998), and the number of data products delivered in response to user requests (approximately 3,300 products delivered projected in FY 1998).

ACCOMPLISHMENTS AND PLANS

In FY 1997, the systems in the Goddard and Langley DAACs completed their initial development to support the TRMM mission. The networks to support TRMM were established and operational readiness reviews for the ground systems were conducted.

A demonstration was conducted in August of the EOSDIS Core System (ECS) software. An external review committee established the criteria which were met during the demonstration. *An* initial set of capabilities for science data processing exists, but are not yet at launch-ready status. The systems needed for controlling the AM-I and Landsat-7 spacecraft, for processing the AM-I data to Level 1, and for doing data transport all reached operational (or near operational) status in FY 1997. There is no question about the readiness of the system to perform these functions for **AM-1** and Landsat-7 at launch in 1998.

A key activity for FY 1997 was the start of a prototyping phase for formation of the Environmental Information Federation. NASA began the selection process of Working Prototype Earth Science Information Partners (WP-ESIPs) by issuing two Cooperative Agreement Notices (CANs) in May 1997 and selected 24 WP-ESIPs. Selection was announced December 2, 1997, with work slated to begin in February 1998. The WP-ESIPs, which come from industrial, educational, and governnient institutions, will develop research data products, provide data products and services having potential commercial value, and apply technology to reduce future EOSDIS cost. The WP-ESIPs will collaboratively establish a working prototype federation and begin exploring federation governance and data center interoperations. Implementation of the federation will occur in parallel to the on-going activities of the EOSDIS DAACs. NASA began a complete peer review and recertification of all the DAACs in FY 1997 based on a list of criteria developed in concert with the NRC.

During FY 1998, the WP-ESIPs were selected and will begin to deliver 'tailored" information products and services to a broad group of science researchers, state, and local agencies, commercial customers, and general interest users, maximizing access to Earth Science program science products and information. Activities of the working prototype federation will occur in parallel with deployment of EOSDIS Version-2.0 at the current DAACs. A key goal for the working prototype federation is to demonstrate the feasibility of science-community governed independent data centers to provide an adequate level of integrated support to the earth system science research community.

In FY 1998, EOSDIS will begin routine production and distribution of the first EOS standard data products from the CERES and Lightning Imaging Sensor (LIS) instruments on the TRMM spacecraft and will provide all mission essential functions to support the AM-1 and Landsat-7 launches. EOSDIS will also support the EOSDIS-EOS Operations Center (EOC) link with Japan to transfer joint data sets. The current DAACs will also complete their recertification activities in FY 1998.

The final automated functions needed in ECS for full AM-1 and Landsat-7 support will be completed in FY 1999 and processing and distribution of AM-1 higher level data products will be increased. Design and development of spacecraft operations and data processing systems needed to support PM-1 will begin in FY 1999. Upgrades to the polar ground stations in Alaska and Norway required to support PM-1 will commence. The working prolotype federation will continue to operate in FY 1999 and NASA will begin to evaluate the federated approach to environmental data and information provisions. NASA will, based on a working prototype federation, begin to transfer responsibility for its product generation, publication, and user services to a full federation in 2000.

BASIS OF FY 1999 FUNDING REQUIREMENT

EARTH PROBES

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Total Ozone Mapping Spectrometer	3.900	8,200	4,900
Tropical Rainfall Measuring Mission	17,300	900	---
Earth System Science Pathfinders	14,000	33,900	70,000
Lewis & Clark	12,000	3,000	5,000
LightSAR	12,000	---	5,000
Experiments of opportunity	2,600	2.600	1,000
Total	61,800	48,600	85.900

PROGRAM GOALS

The Earth Probes program is the component of Earth Science that addresses unique, specific, highly-focused mission requirements in earth science research. The program was designed to have the flexibility to take advantage of unique opportunities presented by international cooperative efforts or technical innovation, and to complement the Earth Observing System by providing the ability to investigate processes that require special orbits or have unique requirements. The currently approved earth probes are the Total Ozone Mapping Spectrometer (TOMS),Tropical Rainfall Measuring Mission (TRMM),Lewis & Clark, Earth System Science Pathfinders (ESSP),and LightSAR.

STRATEGY FOR ACHIEVING GOALS

TOMS

The scientific objectives of the TOMS program are to measure the long-term changes in total ozone and to verify the chemical models of the stratosphere used to predict future trends. The TOMS flights build on the experience that began in 1978 with the launch of a TOMS instrument (flight model 1) on Nimbus-7 and continued with the TOMS instrument (flight model 2) on a Russian Meteor-3, launched in 1991. As with the earlier developments, GSFC has the responsibility for flight project development, and post-launch mission operations and data analysis. The prime contractor is the Orbital Sciences Corporation (OSC) for the TOMS instruments and Pegasus launch services. The remaining development TOMS program consists of one instruments (flight model 5, designated FM-5). The FM-5 has been completed. is in storage. and is scheduled to fly as a cooperative mission with Russia in August 2000.

TRMM

The latent heat released during precipitation is a significant factor in the large-scale computer models used to predict weather and climate change, yet two-thirds of the global rainfall occurs over the tropics where rain measurements are scarce. The TRMM objective is to obtain a minimum of three years of climatologically significant observations of tropical rainfall. In addition, TRMM will provide precise estimates of the vertical distribution of latent heat in the atmosphere. The TRMM data will be used to understand the ocean-atmosphere coupling, especially in the development of El Nino events, which form in the tropics but effects of which are felt globally, causing floods in some areas, yet droughts in others. GSFC has the responsibility for post-launch mission operations and data analysis. The TRMM was launched aboard the Japanese H-II vehicle November 27, 1997.

Earth System Science Pathfinder

The Earth System Science Pathfinder (ESSP) is a science-driven prograni intended to identify and develop in a short time, small satellite missions to accomplish scientific objectives in response to national and international research priorities not addressed by current programs. ESSP will provide periodic "windows of opportunity" to accommodate new scientific priorities and infuse new scientific participation into the Earth Science program. By launching ESSP missions on a regular basis, NASA will provide a mechanism by which pressing questions in earth system science may be addressed in a timely fashion, permitting a continual improvement in our understanding of the earth system and the processes that affect it.

The first two ESSP missions and an alternate mission were selected in March 1997. The Vegetation Canopy Lidar (VCL) mission, led by a University of Maryland, College Park principal investigator is currently in Phase B with an expected launch date of February 2000. The second mission, Gravity Recovery and Climate Experiment (GRACE) led by a principal investigator from the University of Texas at Austin, with significant participation by the Gemian Aerospace Center (DLR), is in an extended Phase B with launch expected in July 2001. A minimum amount of funding is being provided to the Chemistry and Circulation Occultation Spectroscopy Mission (CCOSM) to maintain this spacecraft as an alternate to replace VCL or GRACE if significant difficulties develop.

The second ESSP announcement of opportunity is scheduled for release in the Spring of 1998, with selection planned for December, 1998.

Lewis & Clark

The Lewis and Clark missions were intended to be a new way of doing business for NASA with the satellites being developed, launched and delivered on orbit in 24 months or less with minimal government oversight. The two missions were to demonstrate different land imaging capabilities and other measurements of scientific interest to Earth Science. The Lewis mission was a medium resolution hyperspectral instrument. The Clark mission is a high resolution multispectral imager. The Clark spacecraft is being built by OSC in Rockville, Maryland. The Lewis spacecraft was built by TRW. Lewis was launched in August 1997. Shortly after launch communications with the spacecraft were lost and the cause of the failure is presently under investigation. Clark will carry 36 new technologies including composite structures, advanced avionics and high-efficiency power systems. Clark will have a high-resolution imager capable of 15-meter multi-spectral and 3-meter panchromatic measurements; an instrument to measure pollution in the troposphere; and an X-ray spectrometer to capture bursts from solar flares.

LightSAR

The LightSAR program is consistent with direction included in House Report 104-8 12 which stipulates that NASA's FY 1998 budget request should include additional funding to accomplish this program. LightSAR is a proposed free-flying, earth-observing, lightweight, synthetic aperture radar (SAR) mission. It could be used as **part** of NASA's long-term investment in the development and prosperous use of imaging radar science and technology in the public and private sector. Past spaceborne radar missions have established the vast potential of imaging radar for expanding scientific knowledge of the earth and planets. LightSAR could demonstrate new technologies that reduce the cost and enhance the performance of SAR missions and could contribute to the next level of expansion for the U. S. commercial remote sensing industry. A decision to pursue the LightSAR mission will be made when appropriate data are available.

Experiments Of Opportunity

This program offers a unique capability to undertake short duration flights of instruments on the Space Shuttle and other platforms. The Earth Science program has used the capability of Shuttle/Spacelab development in the important areas of design, early test and checkout of remote sensing instruments for free flying missions, and short term atmospheric and environmental data gathering for scientific analysis. Instrument development activities have supported a wide range of instrumentation, tailored for Space Shuttle and airborne missions.

MEASURES OF PERFORMANCE

Launch Lewis & Clark

Lewis Plan: June 1996
Lewis Actual: August 1997
Clark Plan: June 1996
Clark Revised: Under review

NASA and industry plan was to meet the commitment for a 24-month period between contract initiation and launch of each spacecraft. The Lewis mission was launched, however, a cataslrophic failure occurred and the mission was lost. The failure investigation is continuing.

Launch of TRMM
Plan: August 1997
Actual: November 1997

Launched aboard the Japanese H-II launch vehicle.

Launch Vegetation Canopy Lidar
Plan: 1999
Revised: 2000

The Vegetation Canopy Lidar (VCL), the ESSP mission 1, is scheduled to launch in April 2000.

Launch Gravity Recovery and Climate Experiment
Plan: 2001

The Gravity Recovery and Climate Experiment (GRACE) scheduled to launch in 2001.

ACCOMPLISHMENTS AND PLANS

In FY 1997, the interface adapter module for the interface to the Russian Meteor-3M began development for the TOMS flight model-5.

TRMM was successfully launched on Japan's H-II vehicle from Tanegashima Space Center, Japan on November 27, 1997.

The first ESSP announcement of opportunity was released in FY 1996 and the selection occurred in March 1997. The first two missions are the Vegetation Canopy Lidar (VCL) and the Gravity Recovery and Climate Experiment (GRACE). The second ESSP AO is currently scheduled for release in FY 1998.

Lewis was launched on August 23, 1997 on a Lockheed Martin Launch Vehicle (LMLV-1). Shortly after launch on-orbit communications with the spacecraft were lost. Failure review activities are continuing. The planned launch date for Clark is currently under review due to spacecraft development delays and the availability of a launch position.

The experiments of opportunity program supports flight instrument opportunities on foreign spacecraft, such as the cooperative commercial flight of MAPS on the MIR space station in FY 1997 and the provision of Global Positioning Satellite (GPS) receivers for the *Satellite de Applicaciones Cientificas-C* (SAC-C) satellite with the Argentine Space Agency. The STS 85 mission which included the Solar Constant (SOLCON), Shuttle Laser Altimeter #2 (SLA-02); and Infrared Spectral Imaging Radiometer (ISIR), instruments was successfully completed in August 1997. The STS-87 mission which carried the Shuttle Ozone Limb Sounding Experiment (SOLSE) and Limb Ozone Retrieval Experiment (LORE) instruments was also completed in November 1997.

In November 1997, the four independent industry teams reported their findings on innovative approaches to government-industry teaming, and concepts for maximizing commercial investment in LightSAR. Results of these studies concluded that LightSAR has the potential to produce important science results while opening new markets and creating lucrative long-term sustainable businesses. All of the industry teams recommended that NASA should move forward with LightSAR, and they are prepared to participate and invest in the next phases of a LightSAR government-industry partnership. These results will be considered in NASA's decision whether or not to pursue a LightSAR mission.

BASIS OF FY 1999 FUNDING REQUIREMENT

APPLIED RESEARCH AND DATA ANALYSIS

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Earth Science Program Science	318.300	294.100	294,900
Data purchase	(50,000)	(---)	(---)
Research and analysis	(148,700)	(163,700)	(159,100)
EOS science	(37,500)	(37,400)	(40,900)
Mission science teams and guest investigators	(41,800)	(45,900)	(48,000)
Airborne science and applications	(19,000)	(20,700)	(20,1001
Uncrewed aerial vehicles (UAV)	(300)	(1,900)	(2,000)
Advanced geostationary studies	(2,000)	(3,000)	(---)
Commercial remote sensing	(19,000)	(21,500)	(24,800)
Operations, Data Retrieval, and Storage	75.000	70.300	70,500
Mission operations	(38,200)	(47,700)	(49,900)
High performance computing and communications	(28,300)	(18,300)	(14,500)
Information systems	(8,500)	(4,300)	(6,100)
Total	393.300	364,400	365.400

PROGRAM GOALS

The goal of applied research and data analysis is to advance our understanding of the global climate environment, the vulnerability of the environment to human and natural forces of change, and the provision of numerical models and other tools necessary for understanding global climate change.

STRATEGY FOR ACHIEVING GOALS

The applied research and data analysis program is divided into two components: Earth Science program science and Earth Science operations, data retrieval, and storage. The activities under Earth Science program science include research and analysis, EOS science, airborne science and applications. the purchase and management of scientific data, commercial remote sensing and Uncrewed Aerial Vehicle (UAV) science program. Operations, data retrieval and storage consists of several independent activities responsible for the operation of currently functioning spacecraft and flight instruments, high performance computing and communications. and the provision of computing infrastructure. Each of the major components of applied research and data analysis has its own set of goals, strategies for achieving goals, performance measures, and accomplishments and plans.

BASIS OF FY 1999 FUNDING REQUIREMENT

EARTH SCIENCE PROGRAM SCIENCE

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Data purchase	50.000	---	---
Research and analysis	148,700	163,700	159,100
EOS science	37,500	37,400	40,900
Mission science teams and guest investigators	41,800	45,900	48,000
Airborne science and applications	19,000	20,700	20.100
Uncrewed aerial vehicles (UAV)	300	1,900	2,000
Advanced geostationary studies	2,000	3,000	---
Commercial remote sensing	19.000	21,500	24.800
Total	318,300	294,100	294,900

PROGRAM GOALS

The goal for the Earth Science science program is to contribute to the integration of the earth and environmental sciences into an interdisciplinary scientific understanding of the earth system and the effects of human-kind on the global environment. Major emphasis is placed on providing early warning and fast response to global environmental changes which pose risks to society. The science program also provides the analysis and integration of critical data and models needed for national and international assessments. An objective of current planning is to achieve the most essential, long-term objectives of EOS, and to increase effort on science with near-term payoff, within a sustainable level of funding. The observational program will become resilient, better, and cheaper in the future by (1) taking advantage of the experience being gained in preparation of the first round of EOS flight missions to reduce observing requirements in the future and to simplify the design of instruments for more cost-effective continued operation, (2) finding alternative means to carry out some of the essential measurements at the same level of quality through cooperation with other agencies and nations, and (3) infusing new ideas and technologies into the EOS program through small satellite missions that have lower infrastructure and flight costs.

STRATEGY FOR ACHIEVING GOALS

The Research and Analysis (R&A) science program is essential to the discovery of new concepts and to the design of future missions. The primary mode of research coordination occurs through the USGCRP, the Committee on the Environment and Natural Resources (CENR) Subcommittee on Global Change Research, and the various boards and committees at the National Academy of Science.

The strategy of interdisciplinary research is to increase scientific understanding of the global environment and its vulnerability to both human and natural factors of change (e.g. pollution, climate variability, deforestation). Viewing the earth from space is essential to comprehending the cumulative influence of human activities on its natural resource base. An important priority is to provide accurate assessment of the extent and health of the world's forest, grassland, and agricultural resources. Observations from space are the only source of objective information on the human use of land in a time of rapid land use development. A related priority is to improve understanding and prediction of transient climate variation, such as El Nino anomalies. Reducing uncertainties in climate predictions a season or a year in advance would dramatically improve agriculture and energy utilization planning. Natural hazards research is exploring the use of remote sensing observations for mitigation of drought and flood consequences. There is increasing evidence that predictions of extreme weather events can be improved by understanding their links to interannual climate phenomena like El Nino events. Special attention is being given to measuring and modeling the effects of relative forces like clouds, aerosols and greenhouse gases in long-term climate change, in order to improve our assessments of climate trends on time scales of decades to centuries. A continuing priority is understanding the causes and consequences of changes in atmospheric ozone. Emphasis is now being placed on the changing composition of the lower atmosphere, which is sensitive to the unprecedented increase of pollutant emissions in rapidly developing regions throughout the world. Work will continue in the core research programs in Earth Science.

EOS interdisciplinary science consists of focused research projects to analyze specific Earth Science data sets and interdisciplinary investigations geared for a broader probe into Earth Science system functions. The former is needed to control quality of data produced by interdisciplinary instrument computing facilities and the latter for bridging disciplinary boundaries. Both types of efforts are being supplemented by graduate student participation in the EOS science fellowship program.

There are currently over 1,700 scientific investigations being funded under the research and analysis program. Approximately 900 are carried out by universities, 100 by national research laboratories, and 700 by federal government agencies. The distribution of the activities encompasses forty-five of the fifty states.

The airborne science program funds operations of two ER-2 and one DC-8 aircraft. A C-130Q is also being used to support selected Earth Science investigations. The program funds operation and support of a core of remote sensing instruments and a facility for analyzing and calibrating data from those instruments. The specifically modified aircraft serve as test beds for newly developed instrumentation and their algorithms prior to spaceflight. The instrumented aircraft provide remote sensing and in *situ* measurements for many Earth Science research and analysis field campaigns, including stratospheric ozone, tropospheric chemistry, and ecological studies throughout the world. The ER-2 aircraft, in particular, are unique in that they are the highest flying subsonic civilian research aircraft and were key in collecting in situ data for our understanding of ozone depletion and stratospheric transport mechanisms. The DC-8 aircraft provides a unique "flying laboratory" facility for a broad range of disciplines in atmospheric sciences.

The Commercial Remote Sensing Program (CRSP) continues to fund cooperative efforts with industrial partners aimed at enabling development of a viable commercial remote sensing industry. The cooperative effort will work to apply space-based data and instrument technology in the development of usable. customer-defined information products. Industry will make significant co-investments, funding the CRSP at about an equal level with NASA. NASA and industry will work in a "joint discovery" mode to identify requirements for advance remote sensing observations/measurements, e.g., hyperspectral and SAR data which respond to and help satisfy future commercial market demand.

The objectives of the mission science team/guest investigators are to analyze data sets from operational spacecraft that support global climate change research in atmospheric ozone and trace chemical species, the earth's radiation budget, aerosols, sea ice, land surface properties, and ocean circulation and biology. Funding provides for analyzing data from the UARS, TOPEX, Earth Radiation Budget Satellite (ERBS)spacecraft and spaceborne instruments such as Solar Backscatter Ultraviolet (SBUV/2), TOMS, and TRMM.

The exploitation of UARS data still involves more than 100 investigators from the United States and many other countries, notably Canada, the United Kingdom, and France. Key TOMS and SBUV/2 participants include NOAA, Russia and Japan. Key ERBS users include a diverse set of institutions including NOAA (manifested Earth Radiation Budget Experiment (ERBE) sensors on NOM-9 and - 10 in the 1980's), GSFC, LaRC, the State University of New York, Oregon State University, and the Scripps Institution of Oceanography.

The TOPEX users include France (shared in development of the mission), Japan, Australia, tlie United Kingdom, the Netherlands, Germany, Norway, and South Africa as well as JPL, GSFC, Columbia University, the University of Hawaii, the University of Texas, the University of Colorado, Oregon State University, Ohio State University, and tlie Massachusetts Institute of Technology. SeaStar/SeaWIFS principal users include GSFC, the European community, Japan, Canada, and Australia and a diverse group of universities in Florida, Washington, California, Texas, Maryland, and Rhode Island. At present, the largest demand for ocean color data arises from the Joint Global Ocean Flux Study (JGOFS), an international program under the auspices of the Scientific Committee for Oceanographic Research (SCOR) and the International Geosphere-Biosphere Program (IGBP). NSCAT investigators include scientists from JPL, NOAA, and Japan (manifested the NSCAT for flight on their ADEOS-1 spacecraft), and universities in New York, Washington, Oregon, and Florida. TRMM is a joint mission with Japan to measure tropical precipitation from a low inclination orbit. Participants in the analysis of SIR-C/X-SAR data, in addition to JPL, represent nations in almost every continent including Italy, Saudi Arabia, China, Australia, France, Canada, Brazil, the United Kingdom, and Germany.

The Uncrewed Aerial Vehicle (UAV) science program, a new initiative beginning in FY 1997, will augment the Earth Science airborne program by making in situ and remote sensing measurements initially focused on atmospheric sciences; staying over a target for extended periods to measure detailed temporal changes, provide unique views of cloud structures and provide calibration and verification of Earth Science satellite instrumentation.

The advanced geostationary studies will investigate the application of the latest technology in developing small compact geostationary satellites that will support both research and operational objectives. For example, one candidate under consideration has the capability to provide the first adequately calibrated observations from geostationary orbit that support climate research. The satellite and instrument would be developed over a four year time period. The first spacecraft would carry an imager and a second spacecraft would carry a sounder. The imager has spectral bands which provide data on cloud albedo, vegetation, cirrus clouds, cloud ice, limited ozone, and both high-level and low-level water vapor along with total water vapor. This would provide stable measurements for Earth Science research that have previously been unattainable from geostationary orbit.

MEASURES OF PERFORMANCE

The scientific issues of concern to Earth Science are among the most complex and most policy relevant of any major scientific research program. The results of Earth Science program science are critical to the development of sound U. S. and global environmental policy, necessary for the long-term sustainable development.

Funding for Research and Analysis has been increased to provide the resources necessary to involve more of the science research community in the analysis of the Earth Science data. to fill gaps in the science program created by prior year budget reductions, and to allow more of the excellent research proposals to be funded. For example, only 8% of 250 proposals submitted in a recent Land Cover/Land Use NASA research announcement were funded. Some of those rejected had been rated excellent/very good by the peer review process, a clear indication that there was inadequate funding available to enable excellent science in the Land Cover/Land Use area.

Increased funding will have many positive impacts. Examples of these impacts in the core science disciplines include:

- Polar science will be able to begin support of Antarctic research, using NASA and other satellite remote sensing data at this critical time when there is growing evidence of a decrease in Antarctic sea ice extent and its strong influence on global climate.
- Terrestrial hydrology will apply integrated observations and modeling to studies of river basins and watersheds to aid the water resources management of each as a system, including better estimates of floods and droughts.
- Oceanography will contribute critical remote sensing observations to the research program of the interagency U. S. National Ocean Partnership Program (NOPP) which emphasizes practical applications of ocean research such as El Niño forecasts and effects, fisheries management, coastal management, and science education.
- Atmospheric chemistry will enable a new emphasis on applications-oriented research on upper atmosphere meteorology that could be used to provide weather forecasting capability near the tropopause and , in particular, improve aviation-related weather forecasts.
- Increased focus in the U. S. Weather Research program with NASA, NOAA. NSF and DoD, will allow new uses of satellite and airborne remote sensing technologies to improve the accuracy and reliability of weather forecasts for disruptive high impact weather. including hurricane forecasts near landfall.

	FY 1997	FY 1998	FY 1999
Land Cover/Land Use Chance			
Last Year:	Participate in International Field campaign on tropical rain forest climate.	Use satellite methods to determine deforestation rate in South America.	
This Year:	Used satellite methods to determine deforestation rate in South America	Participate in international field campaigns on tropical rain forest climate	Develop pilot data products for global forest cover and finish regional studies

	FY 1997	FY 1998	FY 1999
Long-Term Climate System Variability			
Last Year:	Evaluate tropospheric ozone as a climate driver.	Determine role of volcanic aerosols in climate.	
This Year:	Evaluated tropospheric ozone as a climate driver.	Determine role of volcanic aerosols in climate.	Participate in interagency field studies of cloud-radiation processes in the arctic region.
Natural Hazards			
Last Year:	Initiate program on flood/drought assessment.	Utilize dense array GPS for earthquake studies in southern California.	
This Year:	Initiated program on flood and drought assessment.	Utilize dense array GPS for earthquake studies in southern California.	Transfer NASA developed technology to agencies responsible for disaster mitigation and response.
Atmospheric Ozone			
Last Year:	Establish role of Asian emissions in ozone levels.	Complete assessment of stratospheric chlorine sources.	
This Year:	Conducted intensive balloon and aircraft campaign to study stratospheric chemistry in the Northe m Hemisphere.	Carry out model-based analysis of satellite and aircraft data on atmospheric chemistry to support international assessments	Conduct ground-based, balloon, and major aircraft campaigns to study atmospheric photochemistry and validate satellite measurements

ACCOMPLISHMENTS AND PLANS

In FY 1997, NASA initiated a data purchase program designed to acquire from commercial sources data sets not otherwise available that are necessary to accomplish research goals of earth system science. The purchase is managed by Stennis Space Center personnel. A RFP was issued in FY 1997 to solicit data purchase proposals. On November 17, 1997, eleven offers out of eighteen proposals received were selected for contract negotiations in the first phase of the Earth Science data buy. Data product generation, data archival, science analysis, and all other NASA requirements are included in other elements of the Earth Science budget.

In FY 1997, continuing into FY 1998 and FY 1999, the following are significant accomplishments in the five priority areas on which Earth Science program science is focusing:

Land Cover/Land Use

The program addressed the role of the boreal forest in global carbon cycle and the effects of land cover change in this region on global change. Studies on the scientific questions relevant to sustainable land management and the provision of ecological goods and services were conducted. The objective was to develop the capability to perform repeated global inventories of land-cover and land-use from space, and to develop the scientific understanding and models necessary to evaluate consequences of observed changes. Comparisons of and improvements upon productivity and land cover models will focus on improving the portrayal of transient effects and on incorporating data from EOS AM-1 satellite sensors.

Short-Term Climate Events (Seasonal-to-Interannual Climate Variability)

Research focused on improved understanding of key interactive climatic processes, such as between the ocean and atmosphere, that should lead to an enhanced ability to predict significant variations in the system, including ones that are geographically specific. Predictions of the consequences of these variations on ecosystems and on socioeconomic interests should be enabled. The economic value of useful predictions of events like El Nino and its various regional effects in lhe United States can be measured in proportion to the considerable impacts of such transient climatic anomalies.

Long-Term Climate System Variability

The program emphasized observations and analysis of on-going variations in present climates and their impacts on the environment. in order to improve the understanding of climate processes to the point where useful predictions of regional climate change can be made. This enhanced understanding will enable the early detection of climate trends, the separation of natural variability from forced climate changes, the quantification of sources and sinks of greenhouse gases, the determination of the main climate feedback processes, and diagnosis of the thermal energy, water, ozone, and carbon cycles that couple the main components of the climate system.

Natural Hazards

The program's science research priorities were in selected aspects of disaster reduction where the technology pathway is understood and significant advances may be anticipated within a decade. Deliverables products and scientific progress will include: assessment of the application of precise correlation between surface deformation and seismic or volcanic events and transfer of the operational responsibility for these observations to operational organizations.

Atmospheric Ozone

NASA research continued to characterize the global distribution of ozone, chemically active trace constituents, aerosols, and related meteorological parameters (e.g. temperature), including long-term observations of a subset of these parameters. The purpose is to understand the processes responsible for the chemical transformations of trace constituents, the role of aerosols in affecting atmospheric chemistry, and the transport of trace constituents within the stratosphere, between different atmospheric levels (stratosphere/ troposphere, stratosphere/mesosphere), and between the troposphere and the earth's surface. It also will quantitatively model the trace constituent composition of the troposphere/stratosphere system through the combined application of observations and global models.

BASIS OF FY 1999 FUNDING REQUIREMENT

OPERATIONS, DATA RETRIEVAL AND STORAGE

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Mission operations	38.200	47.700	49,900
(Upper Atmosphere Research Satellite)	(5,300)	(4,800)	(6,700)
(Total Ozone Mapping Spectrometer)	(1,000)	(2,700)	(2,700)
(Ocean Topography Experiment)	(6,800)	(10.700)	(6,700)
(Nasa Scatterometer)	(4,200)	(---)	(---)
(Tropical Rainfall Measuring Mission)	(800)	(11,300)	(10,900)
(Satellite Laser Ranging)	(5,500)	(5,700)	(5,100)
(Earth Science)	(14,600)	(12,500)	(17,800)
High Performance Computing And Communications- Earth And Space Sciences	28,300	18,300	14,500
Information systems	8,500	4,300	6,100
Total	75,000	70,300	70,500

PROGRAM GOALS

The Operations, Data Retrieval and Storage (ODRS) program provides the data and data products from EOS precursor missions, including the UARS, TOPEX, TOMS, NSCAT and TRMM, required to understand the total earth system and the effects of humans on the global environment. The goals of the NASA High Perfomiance Computing and Communications (HPCC) program are to accelerate the development, application and transfer of high performance computing technologies to meet the engineering and science needs of the U. S. aeronautics, Earth Science, and space science communities and to accelerate the implementation of a national information infrastructure.

STRATEGY FOR ACHIEVING GOALS

This program supports the observations and data management portion of Earth Science activities. The program will achieve its goals through the following: mission operations. high performance computing and communications, and information systems. The data and data products from this program have or will migrate to the EOSDIS.

Mission Operations

The objectives of the mission operations program are to acquire, process, and archive long-term data sets and validated data products. These data sets support global climate change research in atmospheric ozone and trace chemical species, the earth's radiation budget. aerosols, sea ice, land surface properties, and ocean circulation and biology. Funding provides for operating spacecraft such as UARS, TOPEX, ERBS, TOMS, TRMM, and processing of acquired data. Key users of UARS data include NOAA, the Naval Research Laboratory, GSFC, JPL, Canada, the United Kingdom, and a number of universities including the University of Michigan, the Georgia Institute of Technology, the University of Washington, the State University of New York, and the University of Colorado. Key TOMS proponents include NOAA, Russia (manifested a TOMS on their Meteor *3* satellite launched in 1991), Japan (manifested a TOMS on their ADEOS satellite launched in 1996). Key ERBS users are a diverse set of institutions including NOAA (manifested ERBE sensors on NOAA-9 and -10 launched in the 1980's), GSFC, LaRC, the State University of New York, Oregon State University, and the Scripps Institution of Oceanography,

During a 3-week period in September and October 1997, the Canadian RADARSAT spacecraft (launched by NASA in November 1995) was turned through 180 degrees so that it obtained high-resolution (25 meters) radar images looking southwards as it passed over Antarctica. Approximately 7000 images were obtained over a total area of 14 million square kilometers to provide the first detailed map of the entire continent, providing a wealth of information that promises to change totally our approach to Antarctic research. Within a few days of the end of the mapping mission, early results had already revealed unsuspected streams of ice draining vast areas of East Antarctica, detailed surface expressions of the underlying bed topography and geology, and outlines of a lake as big as Lake Ontario, that is buried beneath 4 kilometers of ice.

Key participants involved in the Alaska SAR Facility (ASF) include the European Space Agency (ERS-1 and -2), Japan (JERS-1), Canada (RADARSAT), GSFC, JPL, and the University of Alaska which hosts the ASF. Participants in the analysis of SIR-C/X-SAR data, in addition to JPL, represent nations on almost every continent and include: Italy, Saudi Arabia, China, Australia, France, Canada, Brazil, the United Kingdom, and Germany.

The Satellite Laser Ranging (SLR) System is NASA's contribution to a world-wide laser ranging network. In additional to providing extremely precise tracking for a number of spacecraft (including TOPEX and a host of international missions), the SLR network makes significant contributions to Earth Science (such as precise measurements of the gravity field and the station's vertical position with respect to the earth's center of mass).

The Optical Transient Detector (OTD) instrument has numerous customers for data including NASA, NOAA, USAF, Massachusetts Institute of Technology, Texas A&M, University of California at Los Angeles, Colorado State, and international requests for data from Chile: German Aerospace Research Establishment (DLR); University of Frankfurt, Germany; the Swiss Institute of Atmospheric Physics; South Africa; Mexico: Hungary: Tel Aviv University and Haifa University, Israel: the United Kingdom Meteorological Office; France; Potsdam Institute for Climate Impact Research, Germany; and China.

High Performance Computing and Communications (HPCC) - Earth and Space Sciences

The NASA HPCC program consists of five discipline-related integrated projects. These projects are Computational Aerosciences (CAS), managed by the Office of Aeronautics and Space Transportation Technology; Earth and Space Sciences (ESS), managed by the Office of Earth Science; Remote Exploration and Experimentation (REE), managed by the Office of Space Science, National Research and Education Network (NREN), managed by the Office of Aeronautics and Space Transportation Technology, and Learning Technologies (LT). The LT project focuses on providing the technology base and applications to accelerate the implementation of the national information infrastructure and to communicate and distribute science and engineering materials to the education community.

The implementation of the NASA HPCC program is mainly through coordinated activities at NASA field centers. The ESS project, led by GSFC, will work in close partnership with industry, academia and government. The project used the NASA research announcement process lo select ten principal investigator teams and twenty-one NASA/NSF sponsored Grand Challenge investigations and to implement them on advanced parallel computers. The LT project uses remote internet technologies developed by NASA and other federally funded agencies to expand the application outreach of its programs to traditionally unserved communities. The Internet is used as the primary means of providing access to and distribution of science and engineering data.

Information Systems

The Earth Science information system program has been structured to provide a balanced system of high performance computers, mass storage systems, workstations, and appropriate network connectivity between researchers and components of the system. A major portion of the program funding supports operation of a supercomputing center (the NASA Center for Computational Sciences) at GSFC. A full range of computational services are provided to a community of approximately 1,400 users representing all disciplines of earth and space sciences. Users of the supercomputer complex select representatives to an advisory committee who are integrally involved in strategic planning for the evolution of the complex. They provide feedback on user satisfaction with services provided and help establish priorities for service and capacity upgrades. Offsite NASA-sponsored users comprise 25% of the total. The program monitors and participates in advanced technology programs, such as the HPCC program and National Science Foundation's gigabit testbed programs. Program elements at GSFC and JPL are focused on providing early access to emerging technologies for the earth and space science communities. The early access to new technology provides the program with the opportunity to influence vendors and system developers on issues unique to the earth and space science researchers such as data intensive computation and algorithm development. Early access also prepares a subset of the research community to make changes in research methodology to exploit the new technologies and to champion promising technologies to their colleagues and peers.

MEASURES OF PERFORMANCE

OPERATIONAL SPACECRAFT/INSTRUMENTS

Common to all missions: Archive 95% of planned data acquisition	The primary criteria for success of an operational spacecraft is to obtain 95% of the planned data acquisition.
UARS (launched September 1991) continuing operations	The spacecraft launched in September 1991 with an expected five year mission life. It has gone well beyond the expected mission life providing data to support improvements monitoring the processes that control upper atmospheric structure and variability, the response of the upper atmosphere to natural and human-induced changes, and the role of the upper atmosphere in climate variability.
TOPEX/Poseidon (launched August 1992) continuing operations	The spacecraft launched in August 1992 with an expected three year mission life. The extended mission was defined to be three additional years. It is now in the final year of this extended mission life.
ERBS/ERBE/SAGE II (launched Oct. 1984, December 1984 and September 1986) continuing operations	The ERBS spacecraft launched in October 1984. It has gone well beyond the expected mission life.
Alaska *SAR* Facility Missions: ERS-1 (launched 1991) JERS-1 (launched 1992) ERS-2 (launched 1995) RADARSAT (launched 1995) ADEOS (launched 1996)	The Alaska *SAR* Facility is a ground receiving station and data processing station with no "end of life" defined. It supports ERS-1, JERS-1, ERS-2, and RADARSAT. All of these are international missions. There are currently no unique metrics defined for ASF other than the common metric listed above.
OTD (launched 1995) continuing operations	This instrument was launched in 1995 as a six month technology demonstration. It has far exceeded its designed mission life.
TOMS FM-3 and FM-4 (launched July 1996, August 1996) continuing operations	The TOMS-EP spacecraft was launched in July 1996 with an expected five year mission life. It is currently in its primary mission phase. The first global ozone image was produced and released September 13, 1996. Automated processing and distribution of science products began September 20, 1996 and Internet distribution started on October 7, 1996.

TRMM Launched Plan: November 1997	The spacecraft launched in November 1997 with a three year mission life. It is currently in the checkout and calibration phase and will be turned over for routine operations during FY 1998.
SeaStar / SeaWIFS / Ocean Color (Launched August 1997 continuing operations for data processing)	The spacecraft launched in August 1997. This is a data buy from Orbital Sciences Corporation (OSC) and the operation of the spacecraft is an OSC responsibility.

ACCOMPLISHMENTS AND PLANS

Data has been acquired, processed, disseminated, and archived to meet mission requirements for user availability of timely and accurate data products for global and/or regional monitoring purposes from all operational spacecraft and instruments. The current emphasis on global modeling in support of policy decisions on such matters as the impact of deforestation, ozone depletion, and environmental quality worldwide has led to the acquisition and manipulation of unprecedented amounts of environmental data. The accompanying computational demand has led to a doubling of production computing capacity and quadrupling of mass storage capacity in the last two fiscal years. These added demands are being addressed in the agency's initiative to consolidate supercomputer-based information systems.

In the mission operations program, responsibility for assigned missions is assumed **30** days after launch. Data are acquired, processed, disseminated, and archived to meet mission requirements for user availability of timely and accurate data products.

User requirenients will be met in 1998 and 1999 by continuing operations of on-orbit spacecraft and instruments including the UARS, TOPEX, and ERBS missions: and continuing receipt of ERS-1, JERS-1, and RADARSAT data at the Alaska SAR Facility. In addition, OTD, SeaStar/SeaWIFS, TOMS and TRMM. The NSCAT instrument, while no longer operational, is still undergoing levels of data processing.

The TRMM mission will transition to routine operations in 1998. Data processing for the SAGE III instrument will begin in 1999.

The Earth Science information systems program will continue to provide a balanced computational environment for NASA science researchers primarily through facilities housed at GSFC and JPL. Partnerships with industry and other federal agencies will be used to assure the presence of the program's requirements in the strategic planning of new computational technologies. Recently initiated cooperative agreements will allow the development of supercomputer applications 10 times faster than today, providing the computational studies necessary to mesh with NASA's observational and theoretical programs.

BASIS OF FY 1998 FUNDING REQUIREMENT

GLOBAL OBSERVATIONS TO BENEFIT THE ENVIRONMENT (GLOBE)

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Global Observations To Benefit The Environment.,............	5,000	5,000	5,000

PROGRAM GOALS

The goal of the Global Observations to Benefit the Environment (GLOBE) program is to link scientific discovery with the education process in the study of the earth as an integrated system. The objective is to bring school children, teachers, and scientists together to: (1) enhance environmental awareness of individuals throughout the world: (2) contribute to scientific understanding of the earth: and *(3)* help all students reach higher levels of achievement in science and mathematics.

STRATEGY FOR ACHIEVING GOALS

The GLOBE program is an interagency activity led by NOAA in which NASA has a key role. It involves students (kindergarten through twelfth grade or equivalent) in schools throughout the world, their teachers and the research community. Participating schools are making core sets of GLOBE measurements using GLOBE instruments and procedures under the guidance of GLOBE-trained teachers. The results from all over the world are reported into a central data processing facility. The students then receive feedback and use GLOBE educational materials to understand the compiled results and do their own analyses of the data.

In order to meet the first objective of increasing international environmental awareness, the program has been designed to be international in scope, involving students, educators and researchers from all over the world. By using the Internet to link the schools together, a sharing of discoveries and analysis is encouraged that should result in awareness beyond just the local community.

The second objective to contribute to the scientific understanding of the earth, is achievable due to the expansive data sets that result from long term. repeated measurements made in areas where data has in some cases been extrapolated in the past. To ensure the greatest possible accuracy of the data, international environmental scientists have been involved from the beginning of the program to select a set of significant scientific measurements that can be made by students and define the experimental procedures and data reporting protocols for each.

MEASURES OF PERFORMANCE

Performance Measure	FY 1997 plan	FY 1997 Actual	FY 1998 plan	FY 1998 Revised	FY 1999 Plan
Number of Participating Schools	4,000	4,300	6,000	6,000	8,000

ACCOMPLISHMENTS AND PI

By the end of FY 1997, 4,300 schools around the world have joined GLOBE. Several new types of measurements were added to the program, including coastal ocean measurements for salinity and alkalinity, and soil measurements were also expanded. The GLOBE Teacher's Guide was expanded to include the measurement protocols associated with these new measurements as well as a number of additional learning activities, including those that key to GLOBE's new, on-line visualization capabilities that enable students and others to zoom in on vivid global portrayals of the environment based on GLOBE student data.

In FY 1998, GLOBE will seek to continue to increase the number of partnerships with organizations, such as universities, States and school districts, to help achieve program growth goals with the resources provided by these partners, building on the federal GLOBE science, education and systems infrastructure,, GLOBE will also work toward growth to at least 6,000 schools worldwide as a result of these partnerships. These GLOBE schools will be supported through a new, integrated GLOBE web interface that will provide quick access to the thousands of GLOBE web pages that include data from and information about GLOBE schools and their activities.

During FY 1999, the program will seek to continue to train an increasing number of teachers, thus facilitating the rapid growth in the number of schools participating in the program.

BASIS OF FY 1998 FUNDING REQUIREMENT

LAUNCH SEF

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Mission launch services	70,900	21,400	-.-
Mission support	13.800	13,400	---
Total launch services	84,700	34,800	---
(Launch services distributed to Earth Science missions).....	(17,200)	(53,3001	(100,000)
(Mission support transferred to Human Space Flight).........	[13,800]	[13,4001	(11.600)

PROGRAM GOALS

The goal of the launch services within the Earth Science program is to provide the flight programs with cost-effective, on-time Expendable Launch Vehicle (ELV) launch services.

STRATEGY FOR ACHIEVING GOALS

During the preparation of the 1999 budget, NASA made the decision to transfer the cost of launch services to the flight projects that use the services. Except for EOS AM- 1 and Landsat-7, the project cost for EOS and earth Probes includes launch services. The two exceptions were made because both missions launch in 1998. The purposes of this transfer were first to associate budget, mission responsibility, and accountability as well as to identify the full extent of SAT resources required to satisfy mission objectives.

The launch services budget includes through FY 1998 mission support funding needed to maintain the capability for Earth Science missions. Beginning in FY 1999 the niission support is consolidated with Space Science mission support and budgeted in Human Space Flight.

MEASURES OF PERFORMANCE

EOS AM-1 — To be launched on an Atlas IIAS from Vandenberg AFB.
Plan: June 1998

Landsat-7 — To be launched on a Delta II from Vandenberg AFB.
Plan: December 1998

ACCOMPLISHMENTS AND PLANS

Funding will continue in support of the EOS AM-1 Landsat-7 launches in 1998, and mission support

Aeronautics and Space
Transportation

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TRANSPORTATION TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
Aeronautical research and technology..............................	844,200	907,100	786,000	SAT 4.1-1
Advanced space transportation technology.,......................	336,700	417,100	388,600	SAT 4.2-1
Commercial technology programs	158,600	146,700	130.400	SAT 4.3-1
Total...	1.339.500	1.470.900	1.305.000	

PROGRAM GOALS

NASA's goal is to address priorities for aeronautics and space as outlined by the National Science and Technology Council as part of national aeronautics and space policy. Industry's responsibility is to maintain their near-term competitiveness through evolutionary advancements to their products. The Aeronautics and Space Transportation Technology Enterprise's responsibility is to provide revolutionary advancements in science and technology that sustain global U. S. leadership in civil aeronautics and space. To meet this challenge, three pillars of success have been established. Within these three pillars, a set of ten goals have been defined that address current and future national needs. The technologies associated with these goals are pre-competitive, long-term, high risk research endeavors with high-payoff in terms of market growth, safety, low acquisition cost, consumer affordability and cleaner environment. NASA carries out its aeronautics and space transportation technology mission in close partnership with U. S. industry, academia and other Federal agencies such as the DoD and the FAA.

Pillar One: Global Civil Aviation

Global civil aviation provides the backbone for global transportation, the very basis of global economic and cultural exchange and integration. It is a large and growing market that the U. S. has traditionally led. Projected growth approaches a tripling of air traffic over the next twenty years. Moreover, examination of various alternative futures suggests that there is also the potential for greater dispersion of operations, very high-value for flexible, ultra-reliable operations, and increasing utilization of aircraft with unique operational characteristics.

A need exists to address the fundamental systemic issues for the aviation system to ensure the continued growth and development appropriate to the needs of the national and global economies. These systemic issues—safety, capacity, environmental compatibility, and affordability cut across markets including large subsonic civil transports, air cargo, commuter and general aviation, and rotorcraft. To ensure these systemic issues do not become constraints, dramatic improvements should be aggressively pursued. Therefore, the Enterprise is positioning itself to provide high-risk technology advances for safer, cleaner, quieter, and more affordable air travel by adopting the following five enabling technology goals that cut across all markets in Global Civil Aviation:

- Reduce the aircraft accident rate by a factor of five within 10 years, and by a factor of 10 within 20 years
- Reduce emissions of future aircraft by a factor of three within 10 years, and by a factor of five within 20 years.
- Reduce the perceived noise levels of future aircraft by a factor of two from today's subsonic aircraft within 10 years, and by a factor of four within 20 years.
- While maintaining safety, triple the aviation system throughput, in all weather conditions, within 10 years
- Reduce the cost of air travel by 25% within 10 years, and by 50% within 20 years.

Pillar Two: Revolutionary Technology Leaps

In addition to the systeniic issues associated with the global civil aviation system, there is tremendous opportunity to explore high risk technology to revitalize existing markets and open new markets. Examination of future trends and various alternatives highlighted the opportunities in high speed civil transportation, general aviation and experimental aircraft. In addition to new market opportunities, there exist opportunities to revolutionize the way aircraft are designed and developed. It is also critical to recognize that achieving the goals in all three pillars requires the rapid exploration and validation of concepts and technologies in the flight environment.

The Enterprise will pioneer high-risk technology for revolutionizing air travel and the way in which aircraft are designed, built and operated by focusing on the following enabling technology goals:

- Reduce the travel time to the Far East and Europe by 50 percent within 20 years, and do so at today's subsonic ticket prices.
- Invigorate the general aviation industry, delivering 10,000 aircraft annually within 10 years, and 20,000 aircraft annually within 20 years.
- Provide next-generation design tools and experimental aircraft to increase design confidence, and cut the development cycle time for aircraft in half.

Pillar Three: Access to Space

NASA's primary space launch role is to develop and demonstrate pre-competitive next-generation technology that will enable the comniercial launch industry to provide truly affordable and reliable access to space. NASA and U. S. aerospace companies have embarked on an unprecedented partnership aimed at attaining revolutionary improvements in launch system cost, performance, and reliability. Two enabling technology goals have been established as a part of this Aeronautics and Space Transportation Technology Enterprise:

- Reduce the payload cost to low-Earth orbit by an order of magnitude, from $10,000 to $1,000 per pound, within 10 years.
- Reduce the payload cost to low-Earth orbit by an additional order of magnitude, from $1,000's to $100's per pound, by 2020.

The Reusable Launch Vehicle (RLV) program is developing technologies to achieve the first order-of-magnitude reduction in launch costs, and will demonstrate these technologies by the end of the decade, both on the ground and in flight with the X-33 and X-34 flight demonstrators. The Advanced Space Transportation program focuses on development of those technologies which have the potential to reduce launch and operations costs beyond the ambitious RLV goals as well as technology required to address other strategic objectives not related to the RLV program.

STRATEGY FOR ACHIEVING GOALS

Aeronautics

The aeronautics program addresses critical aeronautical safety, environmental, airspace productivity, and aircraft performance needs at national and global levels. The necessity to strengthen technology development in selected high-payoff areas is vital to the nation's long-term leadership in aviation.

Pillar One: Global Civil Aviation

Great strides have been made over the last 40 years to make flying the safest of all the major modes of transportation. However, even today's low accident rate is not good enough. If air traffic triples as predicted, this accident rate will be totally unacceptable. The impact on domestic and international travel will have adverse economic consequences well beyond the American transportation sector. Dramatic steps. through joint FAA, DoD, and NASA research, will assure unquestioned safety for the traveling public.

Although aircraft produce only a small fraction of the world's air pollution compared to other sources, it is in the best interest of our nation to protect the environment. The U. S. must demonstrate leadership in setting and meeting challenging environmental goals for aircraft. We believe there are technological solutions that will significantly reduce aircraft einissions that contribute to global warming and ozone depletion, even as travel volume increases.

Aircraft noise is the other area where future environmental regulations will challenge us to provide advanced technology concepts and innovations. Previous NASA noise-reduction research is now embodied in new aircraft entering the fleet, and in modifications to existing aircraft.

Airlines and businesses lose billions of dollars annually from delays and lost productivity due to weather and congestion in our severely constrained airspace system. In the next two decades 12,000 new commercial airplanes will be required to accommodate the projected growth in travel and to replace older aircraft. Joint NASA and FAA research into unrestricted flight routing, or "free flight," will allow more aircraft to safely share airspace under adverse weather conditions.

For the aircraft manufacturers, a major challenge is to reverse the trend of increasing costs associated with aircraft ownership and operations. Dramatic time and cost savings in development, production, and certification are needed.

Pillar Two: Revolutionary Technology Leaps

Since the sound barrier was broken 50 years ago, most modern fighter aircraft have the capability to fly faster than the speed of sound. However, today's supersonic aircraft cannot meet international standards for a clean and quiet community nor do they have the maintainability and reliability necessary to be economic contenders in today's commercial transport fleet. To bring this capability to commercial air travel, a number of technical barriers must be overconie.

The general aviation segment of air travel, which includes privately owned aircraft, has tremendous potential for growth if a number of technical issues are solved. At its peak in 1978, the U. S. general aviation industry delivered 17,811 aircraft. In 1996, the number of aircraft delivered had fallen to 1,132 along with a critical tort reform in 1994, the technology innovations anticipated for general aviation will revitalize this industry.

Experimental aircraft are invaluable tools for exploring new concepts, and for complementing and strengthening laboratory research. In the very demanding environment of flight, "X-planes" are used to test innovative, higli-risk concepts, accelerating their development into design and technology applications. In addition to the tools of flight, next-generation design tools will revolutionize the aviation industry. Design was once solely applying ink to paper. Research in information technology will leverage the power of computing tools to reduce time and costs associated with aeronautics research through fuzzy logic and artificial intelligence. These tools will integrate multidisciplinary product teams, linking design, operations, and training databases to dramatically cut design cycle times.

Space Transportation Technology

Consistent with the National Space Transportation Policy, NASA, as a member of the national team, will develop technology for the next generation space transportation system, with a target of reducing launch vehicle development and operations costs dramatically after the year 2000. The Reusable Launch Vehicle (RLV) program utilizes innovative industry-led cooperative agreements to accomplisli technology development research and conduct the technology demonstrations necessary to prove the feasibility of the enabling technologies that will lead to significant reductions in launch vehicle development and operations costs.

Pillar Three: Access to Space

The future of the U. S. space program is hindered by the high cost and low reliability of today's launch systems. The cost of access to space is roughly $10,000 per pound of payload delivered to low-earth orbit. The growth of an otherwise dynamic, creative, and productive U. S. space enterprise is severely impeded by this daunting price tag. Such high cost, for example, means tightly-rationed access to the unique properties of orbital space, thereby significantly reducing the abundant proniise of scientific, environmental, and commercial applications which enrich our quality of life on Earth. High cost also means fewer missions of deep-space exploration that project America's pioneering spirit and expand our knowledge of the solar system. In the last 25 years the U. S. has developed one major launch vehicle and rocket engine. During the same time frame, our international conipetitors have developed 27 rocket engines and many more launch vehicles. Our launchers, once preeminent, now supply only 30 percent of the worldwide commercial market. In the world's rapidly expanding launch business, the U. S. continues to lose market share. To realize the full potential for research and commerce in space, America must achieve one imperative overarching goal: affordable access to space.

Commercial Technology

The third major program area of the Aeronautics and Space Transportation Technology Enterprise is the commercial technology program. Since it's inception in 1958, NASA has been charged with ensuring that NASA-developed technology is transferred to the U. S. industrial community to improve the competitive position of the U. S. in the world community. The scope of the commercialization effort encompasses all NASA technologies created at NASA centers by civil servants as well as innovations from NASA contractors. The technology commercialization program consists of conducting a continuous inventory of newly developed NASA technologies, maintaining a searchable database of this inventory, assessing the commercial value of each technology, disseminating knowledge of these NASA technology opportunities to the private sector, and supporting an efficient system for licensing NASA technologies to private companies. In addition. NASA commercialization efforts also include the operation of the Small Business Innovation Research program, which is designed to enhance NASA's use of small business technology innovators and lead to increased commercialization of NASA technology with small firms.

MEASURES OF PERFORMANCE

The Enterprise has developed, utilizes, and is continually refining a family of performance measures to assess both program progress and relevance to external custonier requirements. These measures fall into four primary categories:

Specific Program Performance: Measures of program performance — both effectiveness and efficiency — relative to program technical, schedule, and resource requirements:

- Implement the Aeronautics and Space Transportation Technology Enterprise progranis in an effective and efficient manner; complete customer-negotiated product and service deliverables (identified as milestones in formal Program plans), within three months of plan.

Customer Satisfaction: Measures of customer satisfaction with respect to Enterprise products and services:

- Satisfy the Enterprise's customers with quality products and services: measure overall customer satisfaction through formal, triennial customer survey.
- Ensure the availability of quality aeronautic facilities for the Enterprise's customers; measure levels of satisfaction with capabilities and services through conduct of exit interviews at selected facilities

Other Organizational Goals and Processes: Measures of performance relative to other key multi-programmatic or non-programmatic policies and goals;

- Increase cooperative programs with the aerospace community; measure number and value of cooperalive programs that embody resource partnerships

Overall Program Outcome: Measures of the long-term impact of the aeronautics program on its customers and on the nation as a whole:

- Increase technology transfer activities with the aerospace community; demonstrate through examples, the application and impact of NASA-developed products and services.

Aeronautical Research
and Technology

SCIENCE. AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TRANSPORTATION TECHNOLOGY **AERONAUTICAL RESEARCH & TECHNOLOGY**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
Research and technology base	404.200	428.300	418.000	SAT 4.1-2
Aeronautical focused programs	440.000	478,800	368.000	SAT 4.1-21
Total	844.200	907,100	786,000	
Distribution of Program Amount by Installation				
Marshall Space Flight Center	6.704	2.228	2.343	
Ames Research Center	192.273	221.266	219.274	
Dryden Flight Research Center	61.903	82.144	67.511	
Langley Research Center	324.020	319.835	258.985	
Lewis Research Center	244.000	251.723	226.158	
Goddard Space Flight Center	6.517	4.173	2.567	
Jet Propulsion Laboratory	1.555	1.436	1.136	
Headquarters	7.228	24.295	8.026	
Total	844.200	907,100	786,000	

BASIS OF FY 1999 FUNDING REQUIREMENT

AERONAUTICS RESEARCH AND TECHNOLOGY BASE

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Information Technology	73,400	74,600	74,000
Airframe Systems	134,700	137,100	139,900
Propulsion Systems	77,000	78,600	73,500
Flight Research	69,600	70,300	68,000
Aviation Operations Systems	17,000	36,300	35,400
Rotorcraft	32,500	31,400	27,200
Total	404,200	428,300	418,000

PROGRAM GOALS

The goal for NASA's Aeronautics Research and Technology (R&T) Base is to serve as the vital foundation of expertise and facilities that consistently meets a wide range of aeronautical technology challenges for the nation. The program is intended to provide a high-technology, diverse-discipline environment that enables the development of new, even revolutionary, aerospace concepts and methodologies for applications in industry. Each element of the Base program has an objective to develop multidisciplinary methods and technology that contributes to one or more of the Aeronautics and Space Transportation Technology Enterprise goals. In particular, the initial $500M commitment over five years of the Enterprise to achieve the goals of the Administration's Aviation Safety Initiative is initially supported from reinvestments made within the R&T Base. Work within the R&T Base lays the foundation for future focused programs to address the long term goals of the enterprise's three pillars. This work constitutes a national resource of expertise and facilities that responds quickly to critical issues in safety, security, and the environment. These same technological resources contribute to the overall U. S. defense and non-defense product design and development capabilities.

STRATEGY FOR ACHIEVING GOALS

The technology environment for success in aerospace is characterized by continuous advances across a wide range of disciplines, as well as developments of revolutionary technology. With the downsizing of research facilities and basic research capabilities in both industry and government agencies, the R&T Base is critical in the continual struggle for technological preeminence in the world-wide aerospace scene. Through basic and applied research in partnership with industry, academia, and other government agencies, NASA develops critical high-risk technologies and advanced concepts for U. S. aircraft and engine industries. These advanced concepts and technologies allow a safe, highly productive global air transportation system that includes a new generation of environmentally compatible, economical U. S. aircraft that are competitive in the marketplace.

The R&T Base is an essential element of the Enterprise, for it is here that new technologies that lead to future advanced aerospace products are conceived. Providing a strong foundation for the fundamental understanding of a broad range of physical phenomena, development of computational methods to analyze and predict physical phenomena, and experimental validation of key analytical capabilities. The R&T Base also develops revolutionary concepts, highly advanced, accurate computational tools and breakthrough technologies that can reduce the development time and risk of advanced aerospace systems and high performance aircraft. A significant portion of the research and concept development in the R&T Base is performed through partnerships and cooperative agreements with the aerospace industry and other government agencies to facilitate rapid technology transfer. Also, the R&T Base supports the vast majority of the Enterprise's peer-reviewed fundamental research with academia and industry. The program also provides the capability for NASA to respond quickly and effectively to critical problems identified by other agencies, industry or the public. Examples of these challenges are found in: aircraft accident investigations, lightning effects on avionics, flight safety and security, wind shear, crew fatigue, structural fatigue, and aircraft stall/spin.

One of the key factors in aeronautical research is an extensive use of research facilities that are located at the four aeronautical research centers: 1) Ames Research Center, 2) Dryden Flight Research Center, 3) Langley Research Center, and 4) Lewis Research Center. Many facilities, such as the National Transonic Facility, the National Full-Scale Aerodynamics Complex, the Icing Research Tunnel and the fleet of research aircraft are unique in the U. S. and even the world. Other factors underpinning continued governmental support of aeronautical research include: the public-good character of much of the research (safety, environment, certification, national security); large disincentives for private sector investment in long term, high risk aeronautical R&T, since an individual company can rarely capture the full benefit; the length of time for the aircraft research-and-development cycle and the total investment recoupment period; the extensive breadth and depth of technologies required to produce a superior aircraft; and the unique cadre of experienced NASA technical personnel.

In FY 1997, the Aeronautics R&T Base restructuring was completed within a framework of six systems-oriented customer-driven programs that serve the needs of the full range of aeronautical vehicle classes. The six R&T Base elements are:

1. Information Technology: The primary focus of this element is on the development of computational tools and integrated systems for the design and manufacture of flight vehicles and systems.

2. Airframe Systems: The Airframe systems technologies have application to all flight vehicles that operate in the atmosphere with emphasis in areas such as: conceptual design; aerodynamic and structural design and development; flight crew station design; and airborne systems design and testing.

3. Propulsion Systems: The purpose of this element is to design and develop efficient, safe, affordable and environmentally compatible propulsion system technologies for subsonic and high speed transports, general aviation and high performance aircraft.

4. Flight Research: The technology developnient under this element is aimed at remotely piloted aircraft, high performance aircraft, hypersonics, and tools and test techniques

5. Aviation Operation Systems (AOS): The AOS is structured to address critical technologies in conimunications, navigation and surveillance systems, air traffic management, relevant cockpit systems, operational human factors, and weather and hazardous environment characterization and avoidance systems.

6. Rotorcraft: The rotorcraft element meets the challenge of technology leadership by developing safe all-weather operations for rotorcraft, low noise technologies, and reducing manufacturing costs.

The ongoing research efforts in the disciplinary areas were evaluated for their potential system-level benefits and transferred to the appropriate newly established program elements. Accomplishments over the past year continue to provide a foundation for longer term technology development to address national needs as outlined in the Enterprise's three pillars for success, and to provide research facilities operations and expert consultation for industry during their product development design and build processes. Conceptual studies took into consideration various state-of-the-art technologies to reduce aircraft design and manufacturing costs and addressed breakthrough technology requirements for future commercial and general aviation transports, rotorcraft, hypersonic vehicles, as well as high performance and high altitude remotely piloted aircraft. The R&T Base continues to sponsor and conduct research using cooperative programs, not only to leverage resources for technology development, but also to ensure timely technology transfers to U. S. customers.

MEASURES OF PERFORMANCE

Information Technology

Deploy Asynchronous Transfer Mode (ATM) technology in Aeronet to increase bandwidth. Plan: August 1997 Actual: August 1997	Increase ATM bandwidth by a factor of ***3*** at a cost less than or equal to that of 1994 Measured cross-country transit time, effective bandwidth, and cost simulated workload on network verified performance projections of network; operational cost reduced by 25%.
Acquire and install High Speed Processor 4. Plan: September 1998	Deliver to NAS community a demonstrated capability of a symmetric multi-processor to deliver scaleable performance at less than 25% of the cost of HSP3.
Demonstrate knowledge system prototype in test facility. Plan: June 1998 Revised: September 1998	Demonstrate reduction in design cycle time by the application of intelligent information analysis and unified instrumentation. Milestone slip due to projected late availability of computer hardware systems.

Adaptive coefficient based controller flight demonstrated in shadow mode on the F-15 ACTIVE aircraft. Plan: December 1998	Achieve neural net reconfiguration in flight.

Airframe Systems

Incorporate economic and risk subroutines into systems analysis methodology. Plan: January 1997 Actual: January 1997	Demonstrate that method is operational and predicts effects of economics and risk on critical design parameters. Redirected systems sensilivities from take-off-gross weight to cost sensitivities as a routine independent variable in systems analysis. Applied and demonstrated method for initial Reduced Cost of Air Travel technology assessments. Developed preliminary relationship between Technology Readiness Level (TRL) and risk.
Demonstrate multidisciplinary modeling, synthesis, and analysis methods to enable efficient and accurate design of control systems for aircraft with complex structural, aerodynamic, and propulsion interactions. Plan: March 1997 Actual: March 1997	Complete and distribute the beta version of software code to industry for application. Developed and demonstrated system software that fully integrates automated control systems in the aircraft design process. Computer design code for the control system distributed to industry.
Develop turbulence model for two-dimensional high-lift flows at realistic Reynolds numbers, Plan: June 1997 Actual: June 1997	Create a turbulence model that predicts wake spreading and slat effects implemented into a 2-dimensional Reynolds-Averaged Navier-Stokes (RANS) code and compare with full scale data. Completed Low-Turbulence Pressure Tunnel Wind-Tunnel data base for assessment of turbulence models.

Complete flight validation of multi-axis control power requirements/design criteria. Plan: September 1997 Actual: September 1997	Validate multi-axis control-power predictions and transfer both design criteria and guidelines to industry. Successfully validated multi-axis control power requirements on the F- 18 high angle of attack research vehicle and **X-3** 1 experimental vehicle. Transferred the design criteria to industry via workshop and proceedings.
Complete Mach 7 Research Vehicle tests in LaRC's 8-foot High-Temperature Tunnel. Plan: February 1998 Revised: March 1998	Coniplete system check-out in Mach-7, flight-type environment and obtain ground based data for direcl comparison with flight. Scheduled wind-tunnel tests moved downstream to accommodate higher priority **X-33** and Navy Standard Missile tesls in facility. Milestone movement does not affect funding or end deliverables.
Verify Electromagnetic Emissions (EME) immunity procedures to emulate specific aircraft EME environment. Plan: September 1998	Complete High Intensity Radiated Fields (HIRF) Laboratory tests to verify EME immunity procedures.
Validate preliminary design concepts for non-circular composite structures. Plan: September 1998 Revised: Deleted	Fabricate and test a non-circular, composite, pressurized structural subcomponent; compare the resulting performance with analytical predictions. Deletion due to reallocation of resources to fund the new Safety initiative.
Mach 7 Research Vehicle Flight. Plan: December 1998 Revised: January 2000	Successfully accomplish research objectives of the dual mode scranijet powered flight tests. Delayed in order to reduce program risk and better fit the funding profile.
Develop technologies for smart aircraft systems to provide cost-effective improvements in boundary layer control. Plan: September 1999	Implementation of active control for 20 percent increase in airfoil maximum lift coefficient.

Propulsion Systems

Develop advanced thermal barrier coatings for ceramic composites and transfer to industry. Plan: February 1997 Actual: February 1997	Demonstrate effective coating in a lab-scale test environment (coated ceramic room temperature strength retained after 100 hours at 1,052 degrees Centigrade hot corrosion). Demonstrated coating process that was accepted and utilized by industry.
Demonstrate advanced, small gas-turbine combustor operating at 3,000°F (+600 degrees Fahrenheit improvement) with minimally cooled liner. Plan: March 1997 Actual: March 1997	Establish design criteria and concept for small engine combustor. Validate combustor in component rig testing. Transfer results to U. S. industry. Demonstrated small combustor by testing it at 3,000°F. Combustor testing at 3,000°F was conducted at various cooling levels. Test results, models and design methodology transferred to industry.
Provide materials systems and processing to enable compressor discharge temperatures of 1,500 degrees Fahrenheit (currently 1,200 degrees Fahrenheit). Plan: April 1997 Actual: April 1997	Demonstrate a compressor disc in a spin-pit test at 1,500 degrees Fahrenheit. Transfer compressor material technology to U. S. engine companies. Identified manufacturing flaws and optimized fabrication process for Metal Matrix Composite (MMC) rings. Ring spin burst test surpassed expected life, producing valuable data. Extensive database developed on the fatigue and failure mechanisms of Titanium-MMCs supporting Mil-Handbook 17 on MMCs. Transferred compressor material technology to U. S. engine companies.
Deliver a preliminary conceptual analysis and design version of the Numerical Propulsion System Simulator (NPSS). Plan: June 1997 Actual: June 1997	Deliver the NPSS to the propulsion and aircraft industry and ensure all critical capabilities are fully functional as judged by the NASA/Industry cooperative technical focus group. Turbofan model was numerically simulated and engine design point was accurately matched. The NPSS program is being directly applied to High Speed Research program. Computer code transferred to industry.
Complete engine fabrication for advanced general aviation turbine and internal combustion engines. Plan: September 1998	Complete fabrication in time to meet FY 2000 flight test schedules.

Provide materials and processing for turbine inlet temperatures above 2,400"F. Plan: June 1999	Environmental durability demonstrated in rig tests above 2,400°F. Burner rig tests and analysis to be conducted using CMC (ceramic matrix composites) Laminated Object Manufacturing (LOM) specimen with cooling holes.
Complete engine pre flight ground tests for GAP engines. Plan: September 1999	Complete altitude test of the turbine engine and the sea level test of internal combustion engine at NASA test facilities.

Flight Research

Complete initial flight evaluation of neural network flight controls. Plan: November 1996 Actual: November 1996	Denionstrate capability to identify key aircraft parameters in flight using a neural net flight controller. Completed flight demonstration in which key F-15 research aircraft parameters were identified in flight.
Demonstrate operability and real time performance optimization of thrust vectoring exhaust nozzles. Plan: September 1996 Actual: December 1996	Using the F-15 research aircraft, quantify performance of "care-free" engine/nozzle operation throughout the flight envelope and demonstrate performance improvements. Completed evaluation of thrust vectoring nozzles on F-15 aircraft. Multi-axis control power predictions validated. Flight test data indicated actual control power obtainable is less than predictions. Designers now have a basis for deciding when higher fidelity predictive tools should be used. Data transfer to industry initiated.
Mach 6.5 scranijet ground test (Russian Central Institute of Aviation Motors (CIAM) contract). Plan: February 1997 Actual: January 1998	Demonstrate system performance and operability in a simulated environment. Delay in initiation was because of cash flow difficulties in Russia and need to upgrade test facility.
Mach 6.5 scranijet flight test (Russian CIAM contract). Plan: April 1997 Actual: January 1998	Demonstrate system performance and operability in flight. Delay in flight test because of cash flow difficulties in Russia. All systems are in place for flight early in 1998.

Complete X-36 flight evaluation. Plan: June 1997 Actual: December 1997	Complete flight objectives and analysis of vehicle performance. Delay was due to the systems and software development for the flight vehicle. Highly successful flight evaluation achieved all program objectives. Measured performance exceeded predictions. Provides credible database for tailless fighters of the future.
Demonstrate solar-powered remotely piloted aircraft (Pathfinder) to 70,000 feet. Plan: September 1997 Actual: July 1997	Using upgraded solar cells, sunlight and FY 1997 configuration/technology on Pathfinder II airplane, achieve maximum possible altitude and duration. On July 7, 1997 the Pathfinder reached 71,504 feet in altitude, exceeding the existing propeller-driven aircraft record by a sufficient margin to qualify as a new World record.
Flight-demonstrate an inlet-distortion-tolerant control system. Plan: September 1998	Evaluate in flight, on the Advanced Control Technology Integrated Vehicle (ACTIVE) aircraft, a high-stability, integrated control systeni using sensed inlet distortion to enhance stability.
Complete unconventional-control tests for "falling leaf' flight experinient. Plan: September 1998 Actual: Deleted	Determine effectiveness of innovative control algorithm to recover from uncontrolled spin/ "falling-leaf' mode using F-18 Advanced Control Research Aircraft (ACRA). Deleted due to unanticipated growth in projected ACRA modification costs. NASA program was refocused and the funds were redeployed on other flight research. Ground test results were transferred to DoD.
Complete piston-powered turbocharged RPA flight for 8 hours at 60,000 feet. Plan: September 1998	As part of ERAST demonstrate record-breaking high-altitude duration capability with hydro-carbon fueled, multi-staged turbocharged piston engine, including sensing of atniospheric scientific data.
Complete significant advance in flight visualization measurement techniques. Plan: September 1999	Flight evaluation of flight measurement and test techniques including in-flight Schlieron imaging system and in-flight infrared transition detection systeni.
Flight demonstrate dropping-of-windsonde compatibility with RPA at altitudes above 55,000 feet. Plan: September 1999	Demonstrate the utility of carrying and delivering miniaturized windsondes (wind measuring sensors) to obtain meteorological data with the Altus Reniotely Piloted Airplane up to 55,000 foot altitude.

Aviation Operations Systems

Demonstrate human alertness monitoring concept. Plan: March 1997 Actual: December 1997	Demonstrate an operational concept for human alertness monitoring. Validated measurement index of alertness in simulation. A manned system configured to adapt to the operator's alertness level measured this way exhibited better performance than a non-adaptive system. Nine month delay due to unanticipated simulator repair.
Coniplete flight tests for the NASA/FAA tailplane icing program. Plan: September 1997 Actual: October 1997	Complete the flight-test development of tailplane aerodynamics in the presence of various ice shapes for several aircraft configuration and flight conditions. Completed flight tests and experimental testing in icing and dry wind tunnels. Developed an analytical flight path simulation program to predict aircraft flight dynamics and tailplane aero-performance. A later completion date allowed for a guest pilot workshop that provided demonstration flights to pilots from FAA, Transport Canada, and aircraft manufacturers including Cessna, Learjet, Raytheon, and DeHavilland.
Complete icing-tunnel database of ice shapes for modern airfoils. Plan: June 1998	Develop a database of two-dimensional ice shapes for modern airfoils based on testing in the NASA Lewis Icing Research Tunnel.
Coniplete flight tests and instrumentation comparison for the NASA/AES Joint Super-cooled Large Droplet (SLD) icing program. Plan: June 1999	Develop SLD icing research data acquisition and processing methods through joint SLD flight operations and collaborative instrumentation development with the Canadian agency.
Develop the model of human memory constraints in reactive planning and procedure execution. Plan: September 1999	Demonstrate, using full mission simulation, safety benefits of automation design using models of human memory.

Rotorcraft

Complete initial civil tiltrotor terminal area simulation using Man/Machine Integrated Design arid Analysis System (MIDAS) to analyze proposed cockpit designs and crew procedures. Plan: June 1997 Actual: June 1997	Obtain human performance and workload data resulting from a notional civil tiltrotor cockpit design applied to a selection of feasible terminal area scenarios. Cockpit designs, alternative crew procedures, arid an automatic discrete nacelle positioning system for a civil tiltrotor were evaluated for a realistic high workload conditions. Testing showed that a high workload in the visual and cognitive channels throughout the mission scenario nears overload conditions, but the automatic discrete nacelle allowed the pilot to perform the mission within time constraints.
Flight qualify Rotorcraft Aircrew Systems Concept Airborne Laboratory (RASCAL) research flight control system. Plan: September 1997 Actual: September 1997	Coniplete airworthiness checks and flight qualification. Flight control system was delivered to NASA.
Validate advanced computational methods for the prediction of rotor/airframe interaction and unsteady aerodynamics with data acquired from advanced laser velociniietry techniques. Plan: January 1998 Revised: January 1999	Publish an assessment of the accuracy of unsteady computational aerodynamic predictions of rotor/fuselage aerodynamic interference, based on validation using advanced, non-intrusive, three-dimensional flow measurements. Additional time required to complete data analysis and a comprehensive validation of computer code.
Demonstrate Master Cure Simulation System (MCSS) for manufacturing thick-composite rotorcraft structures. Plan: September 1998	Under National Rotorcraft Technology Center (NRTC), validate and demonstrate that master cure process molding and controller accurately predict/control thick-composite-material behavior and its rate of cure.

Demonstrate high-quality, low-cost composite manufacturing of critical rotorcraft Components using resin transfer molding process. Plan: September 1999	Improve cost and reliability of components using resin transfer molding process for actual hardware.
Validate prediction of main rotor noise as measured during flight tests, by comparison of measured helicopter footprints with predictions. Plan: September 1999	Provide flight validated computational codes for the prediction of helicopter noise footprints.

ACCOMPLISHMENTS AND PLANS

Information Technology

The Modeling, Analysis, and Design subelement of the Information Technology element made significant progress in FY 1997 in providing the tools and environments necessary for accelerating the aeronautical design process. Database tools, networks, real-time data acquisition and visualization, and user interfaces were developed to compress dramatically the time involved in design cycle iterations. A prototype system has been demonstrated in a production wind tunnel environment. The Integrated Instrumentation and Testing Systems subelement developed complementary capabilities in the area of experimental data acquisition, accuracy, and productivity. New non-intrusive measurement systems were developed that enable more accurate, faster, and more comprehensive data collection for important aerodynamic quantities such as surface shear stress and global velocity fields. On-board sensors were developed and demonstrated that measure engine exhaust temperatures, and intelligent propulsion health monitoring systems showed the capability to detect and accommodate for failures of critical engine sensors. The Intelligent System Controls and Operations subelement made significant progress in understanding and controlling complex systems. An intelligent flight control system is under development that can rapidly reconfigure an aircraft's control system after a major change in its handling characteristics, such as a damaged wing. New analytical methods were developed and applied to predicting faults in flight-critical systems (such as "bugs"in software or integrated circuits). The technique was used to study a conirnercial avionics system and identified previously undetected flaws in the design. The Advanced Computing, Networks, and Storage subelement continued to pioneer the implementation of large-scale computing systems for scientific applications. The wide-area network that supports aeronautics research across the country, Aeronet, was upgraded to Asynchronous Transfer Mode (ATM)technology, which provided users with greater bandwidth while reducing the operational cost and providing a growth path for the future. A promising new high-performance computing system was brought on line arid has demonstrated a performance potential of 5 GFLOPS (billion floating-point operations per second), again at significantly lower cost and with growth opportunity for the future. New scientific visualization techniques have been developed that will enable scientists to identify critical features in their datasets rapidly, enabling more efficient, in-depth, and productive investigations of data-intensive experiments.

In FY 1998, a knowledge system prototype will be demonstrated in a wind tunnel test environnient. This system will acquire data from experiments and simulations, rapidly analyze it and provide advisories to test engineers regarding the results and opportunities for design improvements. This system will be fully integrated with newly developed wind tunnel instruments that will reduce the time and cost of aircraft design cycles. Furthermore, new team-based business processes will be implemented for niore efficient program planning, coordination, and distribution of test facility resources amongst NASA's customers and collaborators. An intelligent flight control system will be flight tested on board an F-15 flight research aircraft, a major step forward in demonstrating the potential to regain safe, controllable flight characteristics after a major change such as a damaged wing, greatly increasing the chances for survival and safe return in such circumstances. A communication systeni for the aviation community will be developed that will enable aviation safety information to be accessed, analyzed, and disseminated rapidly throughout the national airspace system, helping to understand current risk factors, identify emerging trends, and address the most important issues in aviation safety. A new high-speed processor, HSP-4, will be obtained and integrated into the aeronautics supercomputing system. This machine will demonstrate sustained processing speeds of 15 GFLOPS (billion floating-point operations per second) for realistic aerospace design and analysis problems, and its price performance and scalability will be evaluated. Tools and techniques to generate safe software automatically for complex, flight-critical systems at greatly reduced time and cost will be developed, as well as the means to protect and verify the integrity of data communications within the aviation system.

In FY 1999, the Information Technology element will continue its advancement of integrated design techniques, including wind tunnel flow quality and testing productivity enhancements, more accurate model positioning arid balance calibration systems, on-line real-time test data and more versatile user interfaces, Together with advanced instruments and data acquisition systems, this effort will establish the capabilities necessary to demonstrate real-time design exploration. An intelligent, neural-network flight control system will be flown on an F-15 research aircraft, and work will be initiated to integrate this capability with propulsion control, health monitoring and diagnosis capabilities. Intelligent tools for an aviation safety data sharing network will be developed and a prototype data sharing network will be established, Next-generation coniputing systems will be developed that take advantage of geographically distributed resources, requiring new capabilities in network quality of service. data storage, retrieval, and analysis, and systeni operations including scheduling. planning, and accounting. Software technology developments will contribute to enhancing the reliability and reducing the cost of producing, verifying, and validating complex, flight-critical systems such as flight control systems. Tools for ensuring and verifying the integrity of wireless data communications will be developed and demonstrated to enhance the safety of the future national airspace system.

Airframe Systems

In 1997, the Airframe Systems element of the R&T Base addressed new breakthrough technologies to enhance the performance, safety, and affordability of next generation aircraft. Systems studies identified key technology requirements for future vehicles and determined their market potential. Economic analyses of an 800-passenger aircraft concept that included year 2020 technologies were completed, and advanced manufacturing methods and benefits of advanced material structures and advanced aerodynamics were identified. Transition, pressure, mean velocity, and the first-ever high-quality Reynolds stress measurements at flight

Reynolds Numbers were completed. These will lead to simpler, faster, more efficient high-lift systems and more accurate design tools. Integrally stiffened curved panels were manufactured, and damage tolerance tests were completed. This technology could potentially reduce the cost of manufacturing airframes by 30 to 50 percent and reduce fuselage weight by up to 6 percent. The lower structural weight also will lead to lower emissions and noise.

Under the safety goal, technology was developed to assess critical digital control computers for susceptibility to electromagnetic environments. Technology for an electromagnetic-effects-immune computing platfonn was demonstrated. Crew Response Evaluation Window technology that permits an evaluator to select and simultaneously view several, previously scattered sources of physiological and behavioral response infonnation in a single, integrated display window was implemented. This eliminated the time required for post-processing of physiological and behavioral response data. To ensure the continued airworthiness of airframes, dependable nondestructive evaluation of aircraft structural bonds was completed. These accomplishments will contribute towards decreasing the aircraft accident rate. Assistance was provided to industry and other government agencies in solving problems encountered in aircraft development. Using piloted simulation, techniques to recover from a full-fledged falling leaf motion of military aircraft were developed. This will reduce aircraft incidents and losses and improve operational effectiveness.

The Hyper-X Program will demonstrate in-flight performance of a hypersonic aircraft configuration with an airframe integrated, dual mode scramjet engine. The contract for the Hyper-X launch vehicle was awarded to Orbital Sciences, and the contract for the fabrication of the Hyper-X research vehicle was awarded to a team led by MicroCraft (a small business) that includes Boeing-North American, Accurate Automation, and the General Applied Science Laboratory. In the development process of a scranijet engine for Hyper-X, design tools developed by the National Aerospace Plane Program were utilized. Wind tunnel tests of this engine showed the best scranijet performance ever achieved. In addition to engine wind tunnel tests, a number of wind tunnel tests of models of the Hyper-X research vehicle and models of the Hyper-X research vehicle/launch vehicle stack were completed. Significant research to develop and use advanced analysis and prediction methods to predict performance was completed. The successful development and demonstration of these advanced methods will lead to reduced design cycle times for hypersonic vehicles.

During FY 1998, the Airframe Systems element will develop technology for the area of Safety with flight deck designs that minimize human operational errors and that are error-tolerant to flight crew and aircraft system errors. Efforts to assure the continued airworthiness of the aging commercial aircraft fleet will focus on nondestructive techniques for evaluating the integrity of thick structural components in aging airframe structures, on enhancing human survivability in the event of accidents, and on improving aircraft landing dynamics. These technologies will continue to contribute in decreasing the aircraft accident rates. To enhance Environmental Compatibility of aircraft, the program will develop smart materials, aeroacoustic analyses, and fundamental aerodynamics of high-lift systems. To allow for more affordable air travel, the Airframe Systems Program will address key technology barriers for future subsonic transports. This includes understanding of viscous scaling for high-Reynolds-Number flows, non-circular pressure structures, and noise reduction concepts to enable revolutionary designs with unprecedented benefits over conventional structures. Integral airframe structures technology will address materials processing science to enable significant reductions in manufacturing costs of fuselage structure by replacing built-up, riveted metallic fuselage structure with large, integral nietallic structure. These technologies will contribute to a decrease in the cost of air travel, Airframe systems concept-to-test efforts will address reduction of aircraft design cycle time through reduced time and cost of analytical solutions, reduced user interaction, increased fidelity of modeling, and integrated analyses. Technologies that contribute to reduced aircraft takeoff gross weight and increased agility while allowing fighter aircraft to meet survivability requirements will be developed. These technologies include innovative control effector concepts, multi-element control law design methods, and active buffet alleviation and aeroelastic control. Developnient of new air vehicles and concepts will be supported actively through technical cooperation with industry and the Department of Defense. This includes wind-tunnel tests and other NASA support for the development of the Joint Strike Fighter. Continued assistance in solving technical problems with existing aircraft will be provided. The first fully powered Hyper-X vehicle pre-flight tests in Mach-7 flow in a large-scale wind-tunnel will be completed. Progress will continue toward integrating the vehicle with a rocket booster in preparation for flight. Subscale engine tests, control law development for flight test, detailed simulation of full flight envelope, and component testing and verification will be completed, in preparation for 1999 flight demonstration.

In FY 1999, the Airframe Systems element will develop technology in Safety with complete simulations of optimized crew workload displays. This will be used to help reduce accidents caused by errors in the flight deck. The technologies will contribute to an additional reduction in the aircraft accident rate. To enhance Environmental Compatibility, breakthrough technologies in active structural control that allow for significant reduction in aircraft bending loads will be developed. The Airframe Systems Program will demonstrate propulsion airframe integration issues for high-by-pass ratio engines and verifying the cost reduction potential and durability and damage tolerance of integrally stiffened metallic fuselage components. Next-Generation Design Tools and Experimental Aircraft will be developed to support the *Revolutionary* Technology *Leaps* pillar. High-payoff, innovative control concepts will be developed and demonstrated, and validated design criteria to address the out-of-control "falling-leaf' phenomenon associated with fighter aircraft will be provided. The first Hyper-X vehicle will have completed flight tests at Mach 7. Comparison of CFD performance prediction and correlation with wind tunnel data will begin. Design and test of the Mach 5 engine will be completed and full scale wind tunnel test of the Mach 5 configuration will be underway.

Propulsion Systems

In FY 1997, the Propulsion Systems element completed the preliminary design reviews of both the internal combustion and turbine engines intended to power the General Aviation Propulsion flight demonstrations in 2000. A small turbine engine test bed aircraft (VJET II) was rolled out and demonstrated at the 1997 Oshkosh Air Show with a stand-in cruise missile powerplant. In the High Performance Aircraft subelement, an engine turbocooler was demonstrated which utilizes conventional jet fuel as a heat sink. This requires a coating to prevent fuel coking products being deposited in the fuel lines and injectors. A temperature of 732°F (compared to the 1000°F goal) was demonstrated prior to an unrelated secondary system failure. Plans for resumption of tests were pursued with DoD and industry partners, as it is particularly well-suited for supersonic aircraft. A small combustor was demonstrated by testing it at 3,000°F. Combustor testing at 3,000°F was conducted at various cooling levels. Test results, models and design methodology were transferred to industry. A version of the Numerical Propulsion System Simulation (NPSS) intended for use in preliminary conceptual analyses was released in June 1997. The NPSS is a "numerical engine test cell" which will provide faster and cheaper assessments of advanced aeropropulsion concepts. A demonstration of active stall control in a single-stage transonic compressor showed a 25% improvement in stall margin in the presence of distorted inflow. This technology will be extended to multistage compressors by FY 1999. A physics-based model of the forging process for engine components was developed for industry review and evaluation. Such models will be the subject ofvalidation testing in FY 1998 and are designed to provide faster and more efficient transformation of new concepts into prototypes. The metal matrix composite life prediction cooperative endeavor with the U. S. Air Force and all engine companies developed lifing "modules" in support of materials and structures efforts aimed at

1,500°F compressor components. In cooperation with the Flight Research element, the F-15 ACTIVE aircraft was used to demonstrate the HISTEC (high stability engine control) system using sensed inlet distortion to enhance stability.

In FY 1998, the Propulsion Systems element will focus on technology barriers to increased turbine temperature and reduced engine emissions. The element will also initiate a new activity to further enhance engine safety. The temperature barriers will be addressed by improved computational design methods for turbines with reduced cooling flow requirements. Emissions barriers will be addressed by a heightened emphasis on active combustion control technology. The Ultrasafe Engines subelenient will be initiated to develop long-life, durable engine materials/components and to develop enhanced, light-weight engine containment materials/systems. The General Aviation Propulsion subelement has progressed into the hardware building stage. Component testing has begun on the turbine engine and both turbine and internal combustion engines will have full engines assembled and ready for testing. Aircraft engine inlet compatibility testing for the turbine engine demonstrator aircraft will be conducted at the LeRC 8x6 Wind Tunnel. Both engines are scheduled for flight testing in FY 2000. The option to build a turboprop/turboshaft ground demonstrator version of the turbine engine, of common core with the turbofan, will also be exercised. Under the HITEMP element preparations will be underway for the demonstration of 900°F silicon carbide sensor and integrated electronics package on an engine in FY 1999. The High Performance Aircraft subelement will continue active technology validation activities in coordination with DoD. Finally, FY 1998 will see the demonstration of critical technology components for hybrid propulsion systems capable of hypersonic flight.

During FY 1999, the Propulsion Systems element will concentrate on demonstration of two advanced engine technologies: (1) advanced material and process systems capable of inlet temperatures above 2,400°F will be demonstrated and (2) a 900 degree F silicon carbide sensor will be demonstrated on an engine. The General Aviation internal-combustion and turbine engines will be tested at altitude and at sea-level at NASA engine test facilities, in preparation for the flight tests in FY 2000. Life prediction capability for metal matrix composites will be under investigation with industry partners leading to its confident use in design cycles by FY 2000. Cost-effective design methods for design of highly loaded turbomachinery for reduced fuel burn will be under aggressive development for delivery in FY 2000. The High Performance Aircraft subelenient will continue active technology validation activities in coordination with DoD. Preparations for FY 2000 demonstrations of active control of compressor stall in the most modern multi-stage machine will be underway. Subscale composite engine containment concepts will be evaluated in a laboratory setting as a first step toward developing high risk, high pay-off, light weight containnient technology to enhance aviation safety.

Flight Research

In FY 1997, the Flight Research element, under the environment goal under Environmental Research Aircraft and Sensor Technology (ERAST), achieved a significant accomplishment with a world-record breaking flight of the solar-powered Pathfinder Remotely Piloted Airplane (RPA) to an altitude of 71,504 feet. This RPA technology will increase the nation's capability to make scientific sampling high in the atmosphere. In pursuit of efficiency and affordability, the F-18 Systems Research Aircraft is used to evaluate advanced control system components including fiber optics, electrical actuators, etc. In pursuit of survivability, the X-36 has made a very successful series of flights. The airplane has proven to be very robust for a one-of-a-kind experiniental aircraft. The demonstrated actual performance of X-36 in flight far exceeds it's predictions. It has also demonstrated the viability of a rapid-prototyping manufacturing technique which provided dramatic cost savings in aircraft developnient. In pursuit of improved U. S. aircraft and engine performance, within the Integrated Controls area, the Advanced Control Technologies for Integrated Vehicles has demonstrated operability of multi-axis thrust vectoring nozzles. From these tests, designers will be more effective in use of their prediction tools. Under an advanced flight concepts activity, several efforts are underway. A cooperative university and industry effort utilizes formation flight technology to enable very long endurance flight. In an international cooperative program, a scramjet built by the Russian Central Institute of Aviation Motors is undergoing ground test with the flight article nearing flight readiness, investigating the transition from subsonic (ramjet) to supersonic (scramjet)modes. In the PHYSX test program, a Pegasus launch vehicle with a wing glove fixture will measure the cross-flow boundary layer at hypersonic (Mach 8) speed, providing critical design data for vehicles that will provide access to space, The fixture has been installed on the wing and has successfully completed all preflight tests. The flight research testbed aircraft capability is being enhanced through the upgrading of a supersonic-cruise F-16XL to digital flight control system configuration.

The Flight Research element in FY 1998, under the environment goal, will continue to develop a number of concepts through ERAST, including the demonstration of multistage turbocharged RPA to 60,000 feet for an 8 hour duration. This RPA technology will increase the Nation’s capability to make scientific sampling high in the atmosphere. In pursuit of improved aviation safety, a new effort will begin to help transition technology into use by the air transportation industry. This technology will be drawn from the other program elements, and make use of testbed aircraft to raise the technology readiness level. In pursuit of efficiency and affordability, the Systems Research Aircraft will complete the Advanced Actuators Flight experiments activity, which includes several types of electrical actuators, as well as fiber optics technology in the control and feedback sectors. In pursuit of improved U. S. aircraft and engine performance, within the Integrated Controls area, the Advanced Control Technologies for Integrated Vehicles will complete testing of the closed loop multiaxis vectoring nozzles, coupled through a fully integrated interloop flight control system. Under an advanced flight concepts activity, several efforts will be underway. A cooperative university and industry effort will demonstrate two-airplane autonomous formation flight as a step towards developing technology to enable very long endurance flight. The scranijet built by the Russian Central Institute of Aviation Motors will complete its flight test, providing pristine data on the transition from subsonic to supersonic modes. The PHYSX test program will continue providing critical design data for vehicles that will provide access to space.

During FY 1999, flights will begin with the Centurion solar-powered airplane which will be designed to eventually reach 100,000 feet altitude. This RPA technology will increase the Nation’s capability to make scientific sampling high in the atmosphere. In pursuit of improved aviation safety, the effort to help transition technology into use by the air transportation industry will be more prominent. This technology will be drawn from the other program elements, and make use of testbed aircraft to raise the technology readiness level. In pursuit of efficiency and affordability, an F-18 testbed aircraft will be modified to investigate Active Aeroelastic Wing (AAW) technology in preparation for the flight tests which will begin in FY 2000. In pursuit of improved U. S. aircraft and engine performance, under an advanced flight concepts activity, the investigation of unusual low-speed flight characteristics of high-g uninhabited vehicles will make use of low-cost remote-controlled (RC) modeling techniques. Also, a cooperative university and industry effort will demonstrate three-airplane autonomous formation flight as a step towards developing technology to enable very long endurance flight. In the continuing effort to improve flight research tools and test techniques, a significant advance in flight visualization measurement techniques is planned to be fully demonstrated in flight.

Aviation Operations Systems

In pursuit of the goal of improved capacity for the nation's air transportation system, the Aviation Operations Systems element in FY 1997 provided a database and guidelines for achieving robust air-ground communications for air traffic control with varying combinations of voice and datalink communications under differing levels of automation. A field test of advanced vortex sensing system for aircraft spacing was conducted at Dallas-Ft Worth. Wake encounter flight tests were completed using C-130 and OV-10 aircraft. To achieve the goal of improved aviation safety, a set of flights of the NASA/FAA tailplane icing program were completed and the test results will be used to define a database of tailplane aerodynamics with and without icing for various airplane configurations and flight conditions. The first set of flight tests for the Super-cooled Large Droplet (SLD) icing program was completed, the results to be used to define the environment and support the development of simulations tools and weather forecasting/prediction tools. The first-ever survey to examine fatigue factors in corporate operations was conducted in collaboration with the Flight Safety Foundation (FSF) and the National Business Aircraft Association (NBAA).

The Aviation Operations Systems element, in FY 1998, will address key barriers to improving safety and capacity of the nation's air transportation system. In pursuing the goal of improved safety, error-tolerant air-ground integration research will reduce system errors through development of error-detecting/correcting technologies based on human perforniance principles. The physiological and psychological stress factors on humans will be studied, their impact defined, and counter-measures explored. Modeling, wind tunnel, and flight studies will be pursued to understand and characterize the icing environment, to develop technologies to improve forecast and nowcast of icing conditions, to predict its effect on aircraft flight, and to enable design of icing avoidance and protection systems in order to eliminate icing accidents and reduce operational constraints. Advanced tools for converting aviation safety data into operationally useful information will be developed, with emphasis on tools to identify causal factors. accident precursors, and other hidden features in aviation safety data sets.

During FY 1999, the Aviation Operations System element will begin to respond to the President's safety goal of reducing aviation accidents by 5 fold in 10 years. A model of human memory constraints in procedure execution and reactive planning will be developed. This model will be used to guide design of automation to aid air traffic service providers, airline operations center personnel and flight crews to assure automation support consistent with human performance characteristics. Working with industry will continue to improve the effectiveness of ice protection systems and reduced development and certification cycle & costs for industry. International collaboration, needed for dramatic improvements in aviation safety, will be strengthened by a joint Supercooled Large Droplet (SLD) icing research conducted with AES (Atmospheric Environment Sciences) of Canada. To enhance safety, an increased emphasis is being put on the development of procedures and innovations to clarify the roles and responsibilities of aircraft maintenance teams. In addition, to reduce weather related accidents, systems for communicating and displaying real time weather information to airborne and ground base users will be pursued in collaboration with industry and DoD, FAA and NOAA/NWS.

Rotorcraft

During FY 1997 the Rotorcraft element investigated the potential of active controls and tailored rotor characteristics for application to tiltrotor vibration reduction. The results indicated that tiltrotor speed envelop could be safely expanded by 10%. In rotorcraft transmission, a mechanical model for the comprehensive analysis of planetary gearsets was formulated as a first step in the development of design niodules for transmission assemblies and components. A computational code for the analysis of helical gears, that required a supercomputing platform, was converted to run on an engineering work station thereby increasing the potential use of the code leading to the reduction of design cycle time and the cost of rotorcraft. Cooperative flight testing of two aircraft configurations led to a *3* to 6 dB reduction in noise through multi-segmented low noise approaches enabled by Digital Global Positioning Systeni (DGPS) guidance. Rotorcraft Health and Usage Monitoring Systems (HUMS) architecture specifications that have industry, government and supplier consensus, were developed and distributed providing commonality for decreasing cost and increasing reliability. Codes for the analysis of aerodynamic loading were validated to increase design accuracy and reduce the number of iterations or the requirement to stop testing in the flight phase of development to fix problems not accounted for in the initial design process. This effort will contribute towards the goal of a 25% reduction in air travel costs as well as reduced design cycle time. A Rotorcraft Safety Workshop was initiated to determine the common chain of events in rotorcraft accidents. The workshops included participants from government agencies (NASA, FAA and NTSB), rotorcraft manufacturers, rotorcraft operators. The results will be used by all participants in an endeavor to meet the aviation safety goal parameters related to rotorcraft.

In FY 1998 the Rotorcraft element will refine experimental and analytical work to obtain a fundamental understanding of the physics of interactional aerodynamics and validate those processes for new configurations. The creation of mathematical modules for the design process will use fundamental knowledge, valuable input from industry and information technologies. Work on active and passive noise and vibration reduction design techniques, for both conventional helicopters and tiltrotors, will continue. Flight evaluations of helicopter DGPS-coupled precision approach capabilities will be initiated in cooperation with the FAA. Planning will be initiated with a new emphasis in composite structures and materials research for rotorcraft in FY 1998. The National Rotorcraft Technology Center will focus on short term needs while the base program transitions to the higher risk and longer tenn technology development required to meet the challenges of the Enterprise goals. Joint ventures between governnient agencies (NASA and DoD) and industry on a 50-50 cost share basis will ensure reduction in developnient cost and time frame for effective technology insertion.

In FY 1999 the Rotorcraft element will integrate new full-vehicle physics knowledge with advanced, information technology tools to provide accurate, flexible modules suitable for use by industry in their integrated design systems. Additionally, a new emphasis aimed at thick composite structures will be undertaken to reduce parts count and the cost of rotorcraft. Rotorcraft safety will be emphasized in two areas: development of new situational awareness and flight control technologies for accident prevention, intervention, and mitigation as well as continued attention to drive system safety through new, ultra-safe system design concepts and predictive health and life usage management techniques. Noise reduction **will** encompass three areas: 1) more effective noise reduction technologies for the rotor, both passive and active: 2) additional attention to the active reduction of powertrain noise and vibration: and ***3)*** the continued assessment of operations that minimize noise impact on the ground, including the development of codes that can be used by community planners and airport operators. New innovative rotorcraft flight concepts will be actively supported through technical cooperation with DoD and industry. This fourth year of the National Rotorcraft Technology Center (NRTC) will continue to have a significant focus on shorter term technologies to reduce costs and improve affordability, and will see increasing activities in flight safety and reliability. The NRTC will coordinate activities in conjunction with alliances among the FAA, DoD, and NASA to assess the shorter term needs of the program against national needs with a view to maximizing leverage of the NASA investment while minimizing duplication.

Other

During FY 1999, $2 million will be identified to fund the replacement of the composite fan blades for the National Full Scale Aerodynamics Complex (NFAC) at the Ames Research Center. The NFAC is a vital national asset used for fixed wing and rotorcraft take-off, landing, and acoustics research and development. FY 1994 Construction of Facilities (CoF) funds have been identified to fund the design of these blades to assure that acquisition of the new blades can be accomplished before the repaired blades begin to crack. At this time, it is anticipated that the funding source for completion of this work will be either additional prior year funds that may become available after contract close-outs, or funds will be realigned within the FY 1999 Research and Technology Base for program direct CoF.

BASIS OF FY 1999 FUNDING REQUIREMENT

AERONAUTICAL FOCUSED PROGRAMS

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
High-performance computing and communications	23,300	45,700	20,600
High-speed research	243,100	232,000	190,000
Advanced subsonic technology	173,600	201,100	157,400
Total	440,000	478,800	368,000

NASA's Aeronautics focused programs address selected national needs, clearly defined customer requirements and deliverables, critical program decision and completion dates, and a specified class of research with potential application. Each of the focused programs are discussed in detail on the following pages.

BASIS OF FY 1999 FUNDING REQUIREMENT

HIGH PERFORMANCE COMPUTING AND COMMUNICATIONS

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
High-performance computing and communications			
Computational Aerosciences..	23,300	45,700	20,600

PROGRAM GOALS

As a key participant of the Federal HPCC program, the primary purpose of NASA's HPCC program is to extend U. S. technological leadership in high-performance computing and communications for the benefit of NASA stakeholders: the U. S. aeronautics. Earth and space sciences, and spaceborne research communities. As international competition intensifies and as scientists push back the frontiers of knowledge, leading-edge computational science is more important than ever. Studies have shown that high performance computing technologies have a significant positive impact on job creation, economic growth, national security, world leadership in science and engineering, health care, education, and environmental resource management. These technologies also enable the missions of many Federal agencies. The goals of the NASA High Performance Computing and Communications (HPCC) program are to accelerate the development, application and transfer of high performance computing technologies to meet the engineering and science needs of the NASA stakeholders.

STRATEGY FOR ACHIEVING GOALS

The HPCC program goals are supported by these specific objectives:

(1) Develop algorithm and architecture testbeds that are able to fully utilize high performance computing concepts and increase end-to-end performance:
(2) Develop high performance computing architectures scaleable to sustained TeraFLOPS performance;
(3) Demonstrate HPCC technologies on U. S. aeronautics, earth science and space science research problems;
(4) Develop services, tools, and interfaces essential to the National Information Infrastructure;
(5) Conduct pilot programs in public use of remote sensing data that demonstrate innovative use of the National Information Infrastructure;
(6) Conduct research and development towards implementation of the Next Generation Internet (NGI);
(7) Demonstrate innovative use of information technology to improve the quality of science and engineering education.

The Information Infrastructure Technology and Applications (IITA) portion of objectives (4) and (5) has been completed. The learning technology effort has been appropriately realigned in objective (7). The new objective (6) is a result of the Presidential initiative to create the Next Generation Internet.

The NASA HPCC program is currently structured to contribute to broad federal efforts while addressing agency-specific computational problems called Grand Challenges. Specifically, NASA provides resources to develop tools to solve Grand Challenges in four HPCC project areas: Computational Aerosciences (CAS), managed by the Office of Aeronautics and Space Transportation Technology; Earth and Space Sciences (ESS), managed by the Office of Earth Science; Remote Exploration and Experimentation (REE), managed by the Office of Space Science: and Learning Technologies (LT), managed by the Office of Human Resources and Education. An additional component, the NASA Research and Education Network (NREN), managed by the Office of Aeronautics and Space Technology, supports these four projects. The following discussion describes the efforts of the Office of Aeronautics and Space Transportation Technology.

	FY 1997	FY 1998	FY 1999
Aeronautical R&T..	23,300	45,700	20,600
Earth Science	28,300	18,300	14,500
Space Science	3,200	5,600	8,400
Education Programs..	1,400	4,200	4,000
Minority University & Education......................................	2,700	--	--
Total direct HPCC (NASA-wide).............................	58,900	73,800	47,500

The NASA HPCC program is planned and executed in cooperation with Federal agencies, industry, and academia to exchange information about technical and programmatic needs, issues, and trends. Interagency collaboration is fostered through the National Coordination Office which has a full time staff to support the main HPCC coordinating body—the Computing, Information, and Communication R&D Subcommittee **(part** of the National Science and Technology Council).

Interagency Cooperative Programs:

NSF/DARPA/NASA Digital Library Joint Research Initiative - The National Science Foundation (NSF), the Defense Advanced Research Projects Agency (DARPA), and NASA jointly sponsor the Digital Library Joint Research Initiative in order to demonstrate technologies needed to build digital libraries to electronically access NASA science data. This multi-agency effort was initiated in FY 1994 and continues through FY 1998. NASA, in conjunction with NSF and DARPA, co-fund six research and development projects.

Scaleable Input/Output Initiative - This initiative concentrates on research to move massive amounts of data into and out of parallel computers efficiently. Working together, IBM Research, Lawrence Livermore Laboratory, Argonne National Laboratory, and NASA Ames developed a draft standard interface for parallel computer file access. The official MPI-2 standard containing MPI-2 I/O was released in July, 1997 by the world-recognized Message Passing Interface (MPI) Forum. a standards-making organization.

High Performance Networking - Compatible requirements of NASA and the Department of Energy (DoE) for high-bandwidth, wide-area experimental networking led to a joint solicitation and award to Sprint on August 25, 1994, for the incremental delivery of 45 megabits per second (Mbps), 155 Mbps, and 622 Mbps Asynchronous Transfer Mode (ATM)/Synchronous Optical Network Transmission (SONET) service to five NASA centers. The project was completed in September, 1997 and the objectives of this initiative were met on schedule,

Next Generation Internet (NGI) - NASA is a participant in the multiagency NGI effort that also includes the Departments of Defense, Energy, and Commerce, and the National Science Foundation. NGI builds on the base of current NREN R&D activities. NASA-sponsored research will focus on network performance measurement, network interoperability, quality of service and network security. NASA will continue to be an early adopter of emerging networking technologies that chart a course for a robust, scaleable. shared infrastructure supporting lead users from NASA, the research community, and other government agencies.

National HPCC Software Exchange (NHSE) - The Federal HPCC agencies working in concert with academia and DoE laboratories developed a National HPCC Software Exchange to provide an infrastructure that encourages software reuse and the sharing of software modules across organizations through an interconnected set of software repositories. This multi-agency effort was initiated in FY 1992 and continues through FY 1998.

PetaFLOPS Initiative - The current Federal High Performance Coniputing and Communications Program is working toward achieving teraFLOPS (one trillion floating operations per second) computing. However, far-sighted individuals in government, academia and industry have realized that teraFLOP-level computing systems will be inadequate in the future. As a result, NASA, NSF, DoE, DARPA, National Security Agency, and the Ballistic Missile Defense Organization are developing technologies to support PetaFLOP (one million-billion floating operations per second) computing systems.

MEASURES OF PERFORMANCE

Demonstrate end-to-end reductions in cost and time to solutions for aerospace design applications on heterogeneous systems. Plan: September 1997 Actual: September 1997	Demonstrate at least 25% cost reduction in time to solution for 5 applications and a 5-to-1 reduction in time to solution for combustor design application Demonstrated 25% cost reduction by achieving algorithmic improvements that enabled faster calculations without any increase in performance capability of the computer equipment. Compressor code analysis was reduced by 87%, Combustion flow solver was reduced by 80% and speedups translated into ***$3.3*** million savings per design. Also, saved $17 million by performing three-dimensional aerodynamic simulations that reduced the developnient time for a high-pressure compressor by 50%.

Denionstrate cost-effective, high-performance computing at performance and reliability levels equivalent to 1994 Vector Superconiputers at 25% of the capital cost. Plan: September 1997 Actual: September 1997	Solve CAS Grand Challenge problems using a workstation cluster that performs at 250 MegaFLOPS (millions of floating operations per second) at a capital cost of less than $2.5 million, Demonstrated an engine simulation calculated by a cluster of networked workstations with processing power equivalent to a Cray C90 supercomputer for 8% of the cost.
Demonstrate integrated, multidisciplinary aerosciences applications on TeraFLOPS-scaleable testbeds. Plan: September 1997 Actual: September 1997	Demonstrate a Computational Aerosciences (CAS) Grand Challenge application on teraFLOPS-scaleable testbeds–at 50 times baseline 1992 performance, while meeting scalability and portability requirements. Demonstrated incompressible Navier Stokes fluid dynamics calculation at 96 times the 1992 performance baseline.
Install 100-250 GigaFLOPS sustained, TeraFLOPS-scaleable testbed. Plan: June 1998	Install testbed and measure scalability and performance against success criteria.
Denionstrate a portable, scaleable programming and runtime environment for Grand Challenge applications on a TeraFLOPS-scaleable system. Plan: September 1998	Demonstrate that applications scale logarithmically with the number of processors and are portable to all current testbeds.
Demonstrate 200-fold improvement over FY 92 baseline in time to solution for Grand Challenge application on TeraFLOP testbeds. Plan: June 1999	One application from each project in the selected test cases must scale logarithmically or better and have processor factor speed-up at least 50% of ideal, be portable to all testbeds, and perform at 200 times its current baseline.

Demonstrate 500 times end-to-end performance improvement of Grand Challenge and/or NASA mission applications based on FY 96 performance measurements across NASA NREN testbeds over 622 Mbps wide area network. Plan: September 1999	Performed at least three demonstrations at 500 times more end-to-end performance improvement over FY 96 baseline.

ACCOMPLISHMENTS AND PLANS

In FY 1997 the objectives were to (1) demonstrate end-to-end reductions in cost and time to solution for aerospace design applications on heterogeneous systems, (2) denionstrate integrated, multidisciplinary aerosciences applications on TeraFLOPS-scaleable testbeds, (3) demonstrate cost effective high performance computing at perforniance and reliability levels equivalent to 1994 vector supercomputers at 25% of the capital cost, (4) provide a production system software environment that integrates distributed workstations with scaleable TeraFLOPS machines, and (5) demonstrate connectivity among five research centers at four times today's rate (i.e., 622 Mbps as compared to 155 Mbps) over the NASA Research and Education Network (NREN). NASA accomplished all of the FY 1997 HPCC objectives. The Program is investing approximately one million dollars per year on research for technologies leading to PetaFLOPS capabilities. Planning efforts are currently underway to evaluate whether the existing program milestones continue to be relevant given today's technology.

The HPCC program installed a 512 node SGI/CRAY T3E supercomputer at GSFC in June 1997. The Systeni ranks as the largest systeni within NASA, the second largest system available to the U. S. science community, and the eleventh largest in the world.

The Computational Aerosciences (CAS) project enabled one company to achieve a 50% reduction in the development time for building a high-pressure compressor by performing three-dimensional aerodynamic simulations using existing workstations. This impact on development time translated to a $17 million reduction in development cost (56% lower than previous costs), while improving the compressor component efficiency by 2 percent. As a result, the new compressor is expected to result in over one billion dollars in fuel savings during the approximate 20 year life of the engine. CAS was recognized for this work by the Federal CIO Council in its publication "Best Practices in the Federal Government" (Oct. 1997).

Execution time for a combustion flow solver has been reduced by a factor of 5 over its 1995 baseline. Likewise, steady state compressor solver speedup, plus "fine-grain" parallelization of the unsteady compressor solver and improved visualization capabilities have led to (1) achievenient of the overnight turnaround time goal for the aerospace propulsion application Grand Challenge problem and (2) a projected reduction of overall design and development time for a high pressure conipressor from 18 months to 14 months. This translated to a $3.33 million savings in the design of a compressor manufactured by industry partners.

Benchmarking of an 11.5stage high pressure compressor simulation was completed on a SUN workstation cluster. Cost comparison for equivalent sustained 5 GFLOPS performance indicates the cluster cost is less that 8% the cost of a CRAY C90 supercomputer, thus exceeding the 25% milestone metric. This work was performed for the CAS project by Pratt & Whitney under an agreement with the Lewis Research Center.

Many enhancements and/or additions were made to the parallel processing tool suite, including the Automated Instrumentation and Monitoring System (AIMS), Parallel Virtual Machine (PVM), and Portable Parallel/Distributed Debugger (p2d2) a debugger for multi-processed programs that are distributed across multiple heterogeneous machines. AIMS facilitates performance evaluations of parallel applications on multiprocessors. PVM permits a heterogeneous collection of Unix computers hooked together by a network to be used as a single large parallel computer. Thus large computational problems can be solved more cost effectively by using the aggregate power and memory of many computers. High Performance Fortran (HPF) language extensions, including runtime support, were also added to support data parallelism within independently executing tasks. The availability of a commercial version of Load Sharing Facility System Software V3.0 in a large scale production environment will remove critical barriers to widespread use of affordable distributed network computing by U. S. industry. Also the successful pilot experiment "Metacenter" points the way to the technical architecture needed to carry out supercomputing consolidations.

Within Information Infrastructure and Technology Applications (IITA) ninety-two papers were published for a total of two hundred and five since its inception. Its products are in at least 5,300 U. S. schools (20% of which can be classified as under served). IITA web sites currently receive over ten million hits per month. IITA has developed fifteen unique technology models and its projects have received over sixty-seven awards including: The Eisenhower National Clearinghouse (ENC)-Digital Dozen Award; The Rolex Award for Telescopes in Education and the Intergovernmental Open Systems Solution (IOSS) Award for its Distance Learning Course on Telerobotics. Its images were also featured in Time Magazine and in Life Magazine (the Year in Picture). The IITA Project concludes at the end of FY 1997. Most of its Remote Sensing grants and Cooperative Agreements will be completed and respective web products will transition to NASA IV&V servers. IITA educational technology activities will transition to the Learning Technologies (LT) Project. As a result, these new technologies and data libraries will continue to be available to the Agency and the general public.

In FY97 the National Research and Education Network (NREN) project joined the federal Next Generation Internet (NGI) initiative. NASA NREN is installing high speed interconnections with the research networks of other federal agencies and is conducting research into network quality of service issues, During FY97, NREN demonstrated five NASA applications that were not technically possible in using FY96 technology. These real-time applications need uninterrupted data flows and are prone to failure in the presence of communication delays. There were demonstrations of the remote control of a prototype Mars exploration robot; remote visualization and analysis of earth science and Mars Pathfinder data sets; remote reconfiguration and use of an aircraft flight simulator; and remote echocardiographic medical evaluation such as might be needed during NASA spaceflights. These demonstrations were conducted between geographically dispersed points, spanning five NASA centers, and -- via a satellite link -- a remote site in South America.

During FY 1998, the creation of or access to the prototype TeraFLOPS computing facility (testbed) will allow the NASA HPCC program to establish and evaluate prototype systems, subsystems interfaces and protocol standards. The testbed is projected to be capable of executing benchmarks at 100 GigaFLOPS or more than the capability of the current testbed. The prograni is exploring the possibility of joint sponsorship of this testbed with the Information Technical element of the Base Research and Technology Program in order to foster greater efficiency in conducting the objectives of both programs. The project will specifically evaluate CAS and Earth and Space Science (ESS) application codes for scalability to TeraFLOP performance levels on 100-250 GigaFLOPS sustained, scaleable, TeraFLOPS testbeds. The Program also plans to demonstrate a portable, scaleable programming and runtime environment for Grand Challenge (GC) applications on the TeraFLOPS scaleable system. Also in FY 1998, the Next Generation Internet (NGI) project expects to demonstrate a 100-fold increase in capability to access NASA's high performance resources.

In FY 1999 the objective will be to improve time-to-solution for Grand Challenge applications using the existing TeraFLOPS testbed. CAS and ESS applications are expected to perform at 200 times faster than the 1996 baseline. The CAS work will provide improved visualization techniques to reduce design and development time and cost. NREN Efforts will focus on the development and testing of mechanisms for scheduling guaranteed network quality of service to meet real-time bandwidth, latency and error tolerance requirements. This vital work supporting Next Generation lnternet (NGI) will increase the quality, security and certainty of internet transmissions and on the network capable of 1,000 times the capacity of the baseline.

BASIS OF FY 1999 FUNDING REQUIREMENT

HIGH-SPEED RESEARCH

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
High-speed research	243,100	232,000	190,000

PROGRAM GOALS

Studies have identified a substantial market for a future supersonic airliner — or High-speed Civil Transport (HSCT) — to meet the rapidly growing demand for long-haul travel, particularly across the Pacific. Over the period from 2005 to 2015, this market could support 500 to 1,000 HSCT aircraft, creating a multi-billion dollar sales opportunity for its producers. Such an aircraft will be essential for capturing the valuable long-haul Pacific Rim market. Market studies indicate that the successful development of a domestic HSCT will result in $200 billion in sales and 140,000 jobs for U. S. industry. As currently envisioned, an HSCT aircraft would carry 300 passengers at Mach 2.4 on transoceanic routes over distances up to 6,000 nautical miles at fares comparable to subsonic transports.

NASA is developing the technologies that industry needs to design and build an environmentally compatible and economically competitive HSCT for the 21st century. The High-speed Research (HSR) program goal is to have the technology available to enable an industry decision on aircraft production.

STRATEGY FOR ACHIEVING GOALS

While current technology is insufficient, studies indicate that an environmentally compatible and economically competitive HSCT could be possible through aggressive technology development. NASA is concentrating its investments in the early, high-risk stages of development and the aircraft manufacturing industry has indicated that it is willing to make a substantial investment in this program as the technological risk decreases.

NASA's HSR program is providing a public-sector catalyst in addressing this important opportunity with U. S. industry through a two-phase approach. The first phase defined HSCT environmental compatibility requirements in the critical areas of atmospheric effects, community noise and sonic boom and established a technology foundation to meet these requirements. The second and current phase is a cooperative program with U. S. industry and is directed at developing arid validating designs, design methodologies and manufacturing process technology for subsequent application by industry in future HSCT aircraft programs to ensure environmental compatibility and economic viability.

Langley Research Center (LaRC), the lead center, is responsible for policy and program implementation, project planning and funding allocation, vehicle systems engineering arid integration, and direct airframe contractor interface and management. At the

NASA Aeronautics Centers (Ames Research Center (ARC), Dryden Flight Research Center (DFRC), LaRC and Lewis Research Center (LeRC)), the Center Directors provide personnel and facilities to conduct research, analysis and program management in support of the program. LeRC is also responsible for the propulsion contractor interface and management.

The team of primary HSR contractors consists of airframe, propulsion system and advanced flight deck companies. These contractors are responsible for: the research, development and validation of specific technologies: the development and assessment of a next-generation High-speed Civil Transport (HSCT) concept and configuration; the system-level integration of the advanced technologies being developed: and the conduct of associated tasks, such as mission analysis and database development. The primary propulsion contractors are the team of Pratt & Whitney and General Electric Aircraft Engines. The primary airframe contractor is Boeing. The advanced flight deck contractor is Honeywell International. ARC provides significant support directly to LaRC in advanced flight deck development, in computer modeling and simulation, and in economic analysis. DFRC provides support for flight-related activities. LaRC is responsible for integration of all elements of the program and LeRC is responsible for propulsion systems technology integration,

The HSR program is enhanced by participation, in coordination and cooperative efforts to exchange information and data, with other NASA organizations and federal agencies that include:

- The Atmospheric Effects of Stratospheric Aircraft Panel, which includes participation by NASA's Office of Mission to Planet Earth, Environmental Protection Agency, Federal Aviation Administration, National Oceanic and Atmospheric Administration, National Science Foundation and Department of Defense. The panel provides guidance and evaluation of research related to the effects of high-speed civil transports on the upper atmosphere;

- The FAA/NASA Coordinating Committee, which provides the framework for developing and defining HSCT certification requirements: and

- The Department of Defense, which provides a cooperative forum for advanced engine technology development via its Integrated High Performance Turbine Engine Technology (IHPTET) initiative.

The HSR program continues to develop technologies to establish the viability of an economical and environmentally sound High Speed Civil Transport (HSCT), a vehicle that—if built by U. S. industry—could provide U. S. leadership in the long-range commercial air travel markets of the next century, offering returns of billions of dollars in sales and numerous high-quality jobs for the U. S. workers. In FY 1999, NASA has proposed an extension to the program, HSR Phase IIA, which will mitigate risk in two critical areas — propulsion and airframe materials and structures. HSR Phase IIA will enable American taxpayers to continue to receive a return on their investment in high-speed research and will be essential to enabling U. S. industry to make its decisions on whether the 21st Century commercial aircraft market will call for an HSCT.

MEASURES OF PERFORMANCE

Flight Controller Selection (Flight Deck Systems). Plan: April 1997 Actual: April 1997	Make the final program determination of sidestick or wheel and column control inceptor as pilot control mechanism, Include examination of applicable data and studies, potential simulation evaluations, an internal industry review, and a final NASA/industry program selection. Selected center stick configuration because it provides weight and volume gains over wheel and column and has less perceived risk than side stick.
AESA Phase II (Flight Campaign Complete). Plan: August 1997 Actual: August 1997	Complete on-site atmospheric observations with Northern Hemisphere Summer ER-2 flights. Several atmospheric observations were completed: high-altitude balloon experiments (high quality measurements of trace gases and reactive species) and a series of ER-2 aircraft flights over a wide range of latitudes and seasons (data on the transport of emissions from northern latitudes into the tropics).
Engine Static Test (LSM Bld 1) Complete. (Replaces: Testbed Exhaust Nozzle Design — Configuration & Materials, 12/98) Plan: March 1998	Design/Fabrication/Test of a 60%-scale nozzle model. Static performance and acoustic data will be collected. EPM will provide CMC liner panels and thermal protection system to be tested. The propulsion elements of the program were replanned to provide better connectivity between materials and components and to improve the test plan to ensure that testing occurs at appropriate scales.
Combustor Configuration Selected. Plan: May 1998	Combustor selection **will** be based on results of sector testing with advanced metallic and ceramic matrix composite liners, annular rig testing, manufacturing infrastructure assessment, analyses, and preliminary designs of the two most promising combustors. The subscale combustor annular rig tests will not be performed for the rich burn/quick quench/lean burn configuration prior to downselect. This was a result of a management assessment which indicated that the data to be acquired would not impact the downselect.
Preliminary Flight Deck Configuration Selected. Plan: July 1998	Downselection of preliminary flight deck configuration including: choice of control inceptor; selection of basic External Visibility System concept; evaluation of terminal area guidance and control concepts; development of decision-aiding concepts: confirmation of flight deck design and automation philosophy; and provision of both electronic and physical cockpit mock-ups.

Subcomponent Test Articles. Plan: July 1998 Revised: September 1998	Delivery and preparation of several wing and fuselage subcomponent articles for structural testing. Due to changes in agency priorities, the airframe materials and structures milestones have been slipped.
Subcomponent Test Data (Materials and Structures). Plan: July 1998 Revised: September 1998	Release of data acquired during static and damage-tolerant testing of wing and fuselage subcomponent articles. Due to changes in agency priorities, the airframe materials and structures milestones have been slipped.
Component Materials Selection. Plan: September 1998	Materials and structural concepts will be selected for wing and fuselage component test articles. Selections will be based on material performance, structural efficiency, and production costs as determined by testing and analytical studies.
Phase II Assessment of Atmospheric Impact. Plan: September 1998	Complete the assessment of environmental compatibility of HSCT incorporating HSR emissions reduction technology.
Technology Configuration Defined. Plan: December 1998	Define an optimized NASA/Industry technology baseline airplane configuration resulting from HSR technology validation development and down-selection processes. Make final selection of technology elements for the airplane and embody these features in the baseline airplane.
FSD Build 1 Designed: Config./Matl's (Decision). Plan: June 1999	Complete preliminary and detailed design of a full-scale actuated nozzle. Configuration and component material selections determined.
1-Lifetime Accelerated Test Data. Plan: June 1999	initial release of 1-lifetime of data acquired during accelerated thermal-mechanical-fatigue testing of materials: for use in validating analytical methods for predicting material degradation.
Full Scale Annular Combustor, Rig, and Liner Design - Config/Mat'l Plan: September 1999	Detailed design of the selected HSCT scale combustor & life prediction analysis for the liner are complete. Design temperatures & stresses in the liner are within the capabilities of the EPM developed material. Drawings are released for fabrication.

ACCOMPLISHMENTS AND PLANS

In FY 1997, the HSR program made significant progress in developing technology. *An* airframe noise test was completed on a three percent scale model of the high speed civil transport (HSCT) baseline providing an estimate of airframe noise levels and identifying the major noise sources: wing tips, landing gear and nacelles. Initial external vision system flight tests, including 90 approaches and landings in day and night, were completed. Results and comments from piloted operations on NASA's transport systems research vehicle B-737, using video imaging sensors, computer generated imagery, head-up-display-type overlay symbology, and a single 16" high-resolution monitor, were very encouraging. An active, medium-throw center stick was selected as the flight controller for further research. The selection, based on pilot interviews and trade studies, offers weight and volume advantages over a wheel and column and has less risk than a side slick. In wind tunnel testing, a 2D bifurcated inlet model has demonstrated performance, shock stability, and operability that meet anticipated requirements for the HSCT. Weight, cost, and relative risk assessments of all inlet concepts show this inlet to have the best balance of performance and operability with lowest overall risk. Sector testing of two second-generation combustor configurations (lean-premixed-prevaporized moderately mixed multistage radial axial and lean direct injection) demonstrated emission indices (El) of four and seven, respectively (El goal is five). Design improvements were identified to lower emissions in the full-sized combustors. A preliminary design review of four exhaust nozzle component designs was completed. The status of the materials development, scale-up manufacturing plans, benchmark subelement testing, and materials life prediction methods were also assessed. Results indicate the designs are expected to meet all requirements. Two Tu-144 engine ground tests were completed at Tupolev's test facility at the Zhukovsky Air Base, Russia. In the first, eight configurations were tested to determine the effect of aircraft inlet structures on the quality of the airflow entering the engine. **In** the second, 22 transient configurations were tested to determine what happens to inlet and engine performance and stability of operation when supersonic shock waves rapidly change position in the inlet. Based on the results of the Supersonic Laminar Flow Control flight tests, the decision was made not to incorporate this technology into the baseline airplane due to technical risks and extensive system impact. A report detailing the results of the preliminary assessment of the low-speed characteristics of the technology concept airplane was completed. The first eight flights of Tu-144 Flying Laboratory occurred which completed the check-out of the aircraft. Three 12"x12" ceramic matrix composite acoustic tiles and thermal protection system for testing on the first build of the large scale model for the enabling propulsion materials element were delivered. In situ observations during northern hemisphere summer ER-2 flight tests completed the database required for assessing the impact of HSCT engines on the atmosphere. One concept for the main wing body and two concepts for the fuselage were selected for a subcomponent test program based on materials performance, structural efficiency, and producibility as determined by element testing and analytical studies.

The HSR budget for FY 1998 has been reduced by $13 million, reflecting the Agency's proposed transfer of funds into the Space Station Program. During FY 1998, the HSR program will continue developing the technology database to raise the Technology Readiness Levels from 2-3 (technology concept formulated/proof of concept) to 3-4 (proof of concept/component test in laboratory environment). The Tu-144 flight testing will be completed, and experimental data will be reduced, analyzed and compared with HSCT design tools. Analytical methods for accelerating the combined thermal-mechanical-fatigue testing to match real-time degradation parameters for composite and metallic materials will be released. The HSR simulator cab will be integrated on the Langley Research Center Cockpit Motion Facility. Potential flight deck concepts will be installed, including strategic and tactical flight path management, external visibility system display design, and center slick control inceptor, and initial evaluations will be conducted. These data will be utilized to update the flight deck technology configuration benchmark report and 3D electronic benchmark configuration model. Benchmark concepts include those for a functionally integrated flight deck configuration, an external vision system, control laws and flight controller, flight path management (strategic and tactical), crew interaction with automation, crew autoflight integration, multi-function displays/controls, and management of non-normal situations. Design, fabrication and testing of a 60 percent-scale nozzle model will be performed to obtain static performance and acoustic data. Ceramic matrix composite liner panels and thermal protection system will also be tested. Emissions, performance, material durability and operability testing of subscale lean and rich combustor sector at simulated cruise and landing and take-off conditions will be completed on subscale test rigs. A combustor design will be selected based on results of sector testing with advanced metallic and ceramic matrix composite liners, manufacturing infrastructure assessment, analyses, and preliminary designs of the two most promising combustors. The aeroelastic characteristics of the technology concept airplane design will be optimized using multidisciplinary optimization for structures, aerodynamics, propulsion, and controls employing detailed finite element and computational fluid dynamic tools. Several wing and fuselage subcomponent articles will be tested and correlated to analysis predictions. A turbine airfoil alloy will be selected for further development based on results of mechanical and environmental tests, the alloy's compatibility with candidate bond coat/thermal barrier systems, and its demonstrated ability to be manufactured by casting while incorporating potential advanced cooling schemes in its design. The turbomachinery disk alloy and manufacturing process will be selected based on overall ability to meet properties design requirements established during design trade studies. The mechanical properties as a function of the alloy and process variations will be examined. The environmental compatibility of HSCT incorporating new emissions reduction technology will be assessed. The engine concept technical readiness will be reassessed using systems analyses that capture small-scale test results and analysis, material feasibility and manufacturing infrastructure.

Early in FY 1999, the second of three major HSR program milestones — the Technology Configuration — will be completed. The Technology Configuration is an optimized technology baseline airplane configuration resulting from the HSR technology validation development and down-selection processes. Using this baseline, progress toward Technology Readiness Levels of 5 and 6 (subsystem and component validation in relevant environments) will continue in all areas. Wind tunnel and computational fluid dynamics evaluations will be completed on the selected high-lift system for the Technology Configuration. Propulsion/airframe integration issues will be addressed along with powered ground-effects characteristics. Experimental and nonlinear computational inviscid and viscous assessment of the supersonic cruise and transonic cruise performance including the effects of aeroelasticity on the Technology Configuration will be completed. The final nose configuration will be selected based on the satisfactory performance of the external visibility system concept during its flight evaluation. Certification risk from visual through CATIIIb meteorological conditions at suitably equipped runways is an important criteria in the decision. Using the significant experimental database from both ground and flight tests that will be available. the technology configuration's impact on the environment will be evaluated. Preliminary and detailed design of a full-scale actuated nozzle will be completed and the configuration and component materials selections will be determined. Fabrication of advanced material components for the second large-scale model (e.g., ceramic matrix composite acoustic liners, cast superalloy mixer, thermal protection system) will be completed. The initial set of one-lifetime data acquired during accelerated thermal-mechanical-fatigue testing of materials will be released for use in validating analytical methods for predicting material degradation. Drawings will be released of the detailed designs of the selected full-scale annular combustor rig and liner. Life prediction analysis for the liner will be completed. Single materials and structural concepts will be selected for wing and fuselage component test articles and will undergo a preliminary design review. The review will include material performance, structural efficiency, and test costs as determined by subcomponent testing and analytical studies.

Due to the successful results in the existing HSR program, an extension is proposed called Phase IIA. HSR Phase IIA will focus on answering the remaining technology questions on whether U. S. industry will be able to build a viable, economical and environmentally sound HSCT. The work of Phase IIA will be essential to ensuring that taxpayers continue to receive a return on their high-speed research investment dollars and to enabling industry to make a sound business decision on whether a market exists for an American HSCT. To begin in FY 1999, the research will further mitigate risk in two critical areas — propulsion and airframe materials/structures. HSR Phase IIA will deliver well-defined products including propulsion component rig tests, fabrication and ground tests of a full-scale engine and exhaust nozzle, and fabrication and durability tests of major fuselage and wingbox subassemblies using optimized pre-production materials and structures processes. The initial accomplishments in Phase IIA will occur in the propulsion area with initiation of the materials application database for advanced materials required for engine structural design of critical engine components under high-speed civil transport operating conditions. Additionally, design of the full-scale integrated engine/nozzle ground demonstrator will begin.

BASIS OF FY 1999 FUNDING REQUIREMENT

ADVANCED SUBSONIC TECHNOLOGY

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Advanced subsonic technology	173,600	201,100	157,400

PROGRAM GOALS

NASA's role in civil aeronautics is to develop technology to ensure that U. S. industry is prepared to meet the demands and increasing constraints being placed on the aviation system by new safety requirements, increasingly stringent noise and emissions standards. and growing air traffic volume. These constraints slow the introduction of new technology offering improvements in aircraft performance and international competitiveness, because they increase the risk and cost of applying the technology. The goal of NASA's Advanced Subsonic Technology (AST) program is to develop high payoff technologies, in cooperation with the Federal Aviation Administration (FAA) and the U. S. aeronautics industry, to benefit the civil aviation industry and the flying public. These technologies are aimed at reducing travel costs while increasing safety, reducing civil aircraft impact on the environment and increasing the capacity of the airspace system. Success will be measured by how well NASA contributes to: (1) technology readiness that will enable U. S. manufacturers to capture a larger share of the world market for civil aircraft: and (2) the effectiveness and capacity of the national air transportation system.

With competition from foreign competitors greatly increasing, technology is critically needed to help preserve the U. S. aeronautics industry market share, jobs, and balance of trade. Exports in large commercial transports make a significant contribution to the U. S. balance of trade. However, according to industry estimates, the U. S. worldwide market share has slipped from a high of 91% during the 1960's to about 67% today. Increasing congestion in the aviation system and growing concerns about the environmental compatibility of aircraft may limit the projected growth. According to airline representatives, delays in the Air Traffic Control System cost U. S. operators approximately $3.5 billion per year in excess fuel burned and additional operational costs. Also, more stringent noise curfews and engine emissions standards are expected before the end of this century.

Recent meetings with aviation industry CEO's and upper-level managers have identified several critical issues for improving the U. S. air transportation systeni. Among these issues is the need for new methods, tools and technologies to: (1) reduce aircraft design cycle time; (2) increase aircraft performance; and *(3)* reduce the cost of producing, acquiring, maintaining and operating aircraft. In 1997, NASA refocused several elements of the AST program to better respond to the identified requirements. Specifically, the Integrated Wing Design, Propulsion and Composite Wing elements of the AST program were refocused to satisfy the early milestones of a more revolutionary technology thrust to aggressively address these critical needs. In addition, the Technology Integration element was expanded to permit evaluation of the synergism between the various aeronautics-related focused and base program elements within the Aeronautics and Space Transportation Technology Enterprise portfolio.

STRATEGY FOR ACHIEVING GOALS

The AST program was planned and designed to develop, in partnership with the FAA and the U. S. aeronautics industry, high-payoff technologies to enable a safe, highly productive global air transportation system that includes a new generation of environmentally compatible, operationally efficient U. S. subsonic aircraft. The critical needs were selected on the basis of industry/FAA technology requirements to provide a focused and balanced foundation for U. S. leadership in aircraft manufacturing, aviation system efficiency and safety, and protection of the environment. Close coordination exists between NASA and the FAA for the entire program, but particularly in those areas where there is a strong agency synergy: terminal area productivity (TAP), short-haul aircraft, noise reduction, propulsion, and environmental assessment, An ad hoc management review team, comprised of industry and government representatives, provided strategic oversight during the developmental stage. Industry and FAA review progress on a continuing basis to ensure that the program continues to meet those needs.

The development of these technologies is an important step in accomplishing the enabling technology goals of the Enterprise's Pillars, **Global Civil *Aviation*** (Pillar One) and **Revolutionary Technology Leaps** (Pillar Two). Due to the establishment of these goals and the need to aggressively pursue the technology to meet them, the AST program has been refocused. The previous eight program elements of the AST program have been realigned within the following five major elements that are consistent with the national goals defined under the two pillars. These elements are: (1) **Safety** which includes the Aging Aircraft element; (2) **Environment,** including the Noise Reduction and Environmental Assessment elements and the emissions portion of the Propulsion element; **(3) Capacity,** including the TAP, Advanced Air Transportation Technology and Civil Tiltrotor elements; (4) **Reduced Seat Cost,** including the Integrated Wing Design, Technology Integration and Composites elements and the turbine and compressor portions of the Propulsion element; and (5) **General Aviation,** funded under both the Safety and the Reduced Seat Cost elements.

In FY 1997, the elements now contained within the Reduced Seat Cost thrust have been refocused to aggressively pursue technologies that will improve aircraft design cycle time, performance, manufacturing, maintainability. reliability and affordability. These changes included: increasing the focus on engine design cycle, acquisition and maintenance improvements, and deleting the engine seal and some advanced materials work: increasing emphasis on revolutionary vehicle structural configurations and efficient fabrication processes and deleting the full-span composite wing test: greatly increasing the development of advanced configuration designs through design cycle time improvements and deleting the laminar flow control work: and increasing emphasis on systems analysis assessment technology and tools to ensure that the synergistic benefits of these technology advancements is well understood as progress is made in meeting all enabling technology goals in the *Global* Civil Aviation and *Revolutionary Technology Leaps* pillars. In light of Aeronautics program budgetary constraints, it will be necessary to phase out the Reduced Seat Cost effort of the end of FY 1999.

In the Environment Element in FY 1997, in order to accelerate progress toward meeting the goal of reducing emissions in future aircraft, enhanced technology development in the reduction of oxides of nitrogen (NOx) was included in the program with the addition of an advanced combustor sector test for large engines. A corresponding interim goal of denionstrating a 50 percent NOx reduction was added in FY 1999.

Safety

With pressures on the bottoni line, airlines are continuing to fly their aircraft beyond the typical design life of 20 years, or approximately 60,000 flight hours. Today, the average age of the world's operating fleet is over 12 years old, and approximately 1000 airplanes. or one-fourth of the operating fleet, is more than 20 years old. More than 500 of those airplanes are 25 years or older, and some airlines are planning to keep their airplanes flying past 30 years. This trend, simply based on the lower cost of inspection and maintenance versus the cost of acquiring new airplanes, will continue in the future as airlines attempt to attain positive balance sheets. However, the current inspection techniques are based largely on visual methods supported by single point measurements. Due to the reliance on human inspection, the results are subjective and as the airplanes age, inspection becomes more time consuming and costly. To reduce cost and time and eliminate error, methods for predicting the residual strength remaining in aging aircraft and cost-effective, broad-area nondestructive evaluation methods are imperative.

Environment

Aircraft noise is an issue, both nationally and internationally, prompting airports to operate with strict noise budgets and curfews that restrict airline operations. International treaty organizations are actively considering more stringent noise standards which will impact the growth of the aerospace industry. Noise curfews and inefficient noise abatement terminal area procedures exacerbate congestion. In 1969. the FAA issued Federal Aviation Regulation, Part 36 (FAR36) to prevent the increase in noise produced by transport aircraft. In 1991, the FAA took an additional step by requiring that all Stage 2 aircraft be phased out by the year 2000. It is unlikely that the environmental community will tolerate increased overall noise levels due to growth in the number and size of new aircraft after the year 2000. The Noise Reduction element, in cooperation with U. S. industry and the FAA, targets technologies to reduce, by the year 2000. the community noise impact for future subsonic transports by ten decibels (dB) relative to the 1992 state-of-the-art. The approach is designed to develop noise reduction technology for engine source noise, nacelle aeroacoustics, engine/airframe integration, interior noise, and flight procedures to reduce airport community noise impact, while maintaining high efficiency. The objectives will be achieved via systematic development and validation of noise reduction technology. The timing of the technology development is consistent with the anticipated timing of recommendations for increased stringency.

Propulsion emissions has gained significant visibility in international organizations, such as the International Civil Aviation Organization (ICAO),Coniniittee on Aviation Environmental Protection (CAEP). These organizations are considering more stringent standards for engine emissions during landing and takeoff operations—i.e., below 900 meters altitude — as well as new standards for cruise operations. In the past, new combustor concepts and technologies have produced cleaner burning engines to offset the negative trends of more fuel efficient, higher pressure ratio engines. Additional new concepts and technologies, including new higher temperature materials, will be required to meet more stringent standards. In cooperation with the U. S. industry, NASA is developing propulsion technology with the objectives of reducing the environmental impact of future engines through reduced combustor emissions and increasing the competitiveness and market share of the U. S. propulsion industry. The goals of the emissions reduction portion of the Propulsion element are to reduce nitrogen oxide emissions, by at least 70 percent for large engines arid 50 percent for regional engines over 1996 ICAO Standards. Research and development is focusing on low emission combustors. The productions of this element will be incorporated into the next generation of very-high-bypass ratio engines and derivatives or enhancements of engines currently in service.

Environmental Assessment develops a scientific basis for assessing the atmospheric impact of subsonic commercial aircraft. The goals are to determine the current and future impact of aviation on the atmosphere and to provide assessment reports of projected international ozone and climate conditions. Overall program direction and selection of investigators will be guided by an advisory panel comprised of respected members of the scientific and aviation communities. Elements of atmospheric research (e.g. modeling, laboratory studies, and atmospheric observations) are being complemented by studies unique to the aviation problem (engine exhaust characterization, near-field interactions, and operational scenarios). Sensors will be developed to perform atmospheric observations to determine the chemical and physical characteristics of the atmosphere relative to possible effects of aircraft chemistry (i.e., primarily ozone) and climate. The sensors will be used aboard the NASA DC-8 flying laboratory during field campaigns.

Airspace Capacity

Today, airport delays cost U.S. operators more than *$3* billion per year in excess fuel bum and additional operational costs. The number of airports experiencing 20,000 hours of delay each year is projected to increase by 50 percent by 2003. Due to environniental issues and cost, only one major new U. S. airport—in Denver—will be opened this decade. With little ability to build new or expand current airports in the populated areas where they are needed, costs attributed to airport delays will grow. More efficient routing, scheduling, and sequencing of aircraft in all weather conditions is critical to meeting capacity demands. Another part of the solution to capacity demands is to off-load the major airports by developing short-haul routes among the 5200 public-use airports available throughout the country. These short-haul routes could be served by a new fleet of U. S.-manufactured general aviation and civil tiltrotor aircraft. However, during the last 15 years, annual production of general aviation aircraft within the U. S. has fallen to approximately five percent of its 1978 level. U. S. companies no longer dominate worldwide general aviation production—two of the three manufacturers of large business jets are non-U. **S.** companies. As a result, the U. S. trade deficit in this class of aircraft is greater than $800 million.

The U. S. aviation industry is investing $6 billion over 20 years to increase airport capacity. However, a gap exists between the industry's desired capacity and the ability of the National Airspace System to handle the increased air traffic. Additionally, current FAA standards require reduced terminal operations during instrument-weather conditions, causing delays, reducing airport productivity and increasing the cost of operating aircraft. The Terminal Area Productivity (TAP) element is precisely aimed to address airspace capacity. The goal of the TAP element is to increase airport terminal area capacity in non-visual, or instrument-weather, conditions. The technical objective is to provide technologies and operating procedures enabling productivity of the airport terminal area in instrument-weather conditions to safely match that of clear-weather, or visual conditions. By the end of the decade, integrated ground and airborne technology will safely reduce spacing inefficiencies associated with single runway operations and the required spacing for independent, multiple runway operations conducted under instrument flight rules. Single runway operations are expected to increase by at least 12 to 15 percent under instrument weather conditions. In cooperation with the FAA, NASA's approach in TAP is to develop and demonstrate airborne and ground technology and procedures to safely reduce aircraft spacing in the terminal area, enhance air traffic management (ATM) and reduce controller workload, improve low-visibility landing and surface operations, and to integrate aircraft and air traffic systems to address the problems described above. Given the capabilities of future air traffic control automation and improved wake vortex knowledge, "dynamic spacing" between pairs of aircraft types in the landing sequence for a given airport runway systeni is possible and desirable for maximum safety, capacity and efficiency.

The short-haul aircraft can significantly increase capacity and alleviate air traffic congestion problems. To increase capacity the Civil Tiltrotor element offers a unique opportunity to create a new aircraft market while off-loading a large portion of the short-haul traffic from major airports. Studies conducted by Boeing Commercial Aircraft for NASA and the FAA and by various state and local transportation authorities (e.g., Port of New York and New Jersey Authority) have shown the civil tiltrotor to be a viable candidate for relief of air traffic congestion. While the tiltrotor has been shown to be a viable military aircraft (e.g., V-22 Osprey), insufficient research has been undertaken on technologies critical to civil applications such as noise, terminal area operations, safety, passenger acceptance, weight reduction, and reliability. NASA's effort relating to the civil tiltrotor emphasizes development of technology for civil tiltrotor configurations, and focuses on noise reduction: cockpit technology for safe, efficient terminal area operations: and contingency power. To achieve acceptable levels of external noise in the terminal area, proprotor noise must be reduced by six decibels A-weighted (dBA) over current technology. Complex flight profiles involving steep approach angles and niulti-segmented approach paths will be developed to provide an additional six dBA reduction. To enable these approaches to be safely flown under all weather conditions, integrated and automated control laws and displays will be developed. The capability to recover from an engine failure requires the development of contingency power options that can provide single-engine hover capability without excessive engine weight.

Reduced Seat Cost

The focus of the Reduced Seat Cost thrust is to develop and validate aggressive technologies that significantly advance the state of the art in transport aircraft design to insure that the increased air travel requirements predicted for the 21st Century can be adequately satisfied by the U. S.-built aircraft. A second objective of the thrust is to identify and fully exploit the synergism between the various prograni elements which address the Global Civil Aviation and Revolutionary *Technology Leaps* pillars of the Aeronautics and Space Transportation Technology Enterprise strategic goals.

In order to realize this potential, the goal for the Integrated Wing Design element is to enhance delivery of integrated design methodologies, new aerodynamic concepts, and faster design cycles. These concepts and tools will provide superior aircraft and improved market responsiveness while reducing operating and ownership costs, environmental impacts, and aircraft development risks. The technical objective is a demonstration by the U. S. transport aircraft industry that deliverables will provide a three-percent reduction in aircraft direct operating costs (DOC) compared to 1995 baseline technology levels, and a 50-percent reduction in aerodynamic design cycle time over 1995 practices.

Another vital element, Composite Wing Design Methods, is aimed at gaining significant improvements in efficiency of transport aircraft while reducing costs. The goal of this element is to provide validated fabrication methods and models for economic, safe, robust, lightweight composite high aspect ratio wings and revolutionary airframes. The primary technical objectives for the first subelement, Wing Structures, are to verify a composite structure wing design that costs 10 to 20 percent less to acquire and weighs 10 to 30 percent less than an aluminum aircraft sized for the same payload and mission. Significant cost savings are attributed to reducing part count with composite structural concepts and using automated fabrication methods. This equates to a potential savings in aircraft DOC of five percent.

In order to realize the full potential for propulsion capabilities, the goal of the turbine and compressor portions of the Propulsion element is to develop highly fuel efficient, maintainable, reliable and fault tolerant technologies and design methodology which would meet the performance, emissions (including carbon dioxide) and safety requirements for the next generation of air transport systenis. The goals of the element are to improve the DOC by three percent for large engines and five percent for regional engines with fuel efficiency iniprovements of eight to ten percent. Research and development is focusing on affordable advanced turbomachinery: high-temperature disk and blade materials; improved controls and accessories: advanced propulsion mechanical components; and lightweight, affordable engine static structures. Aerodynamic, aeroelastic, and cooling (heat transfer) analytical models and computational tools are being developed and validated using affordable advanced turbomachinery components (which are expected to result in a 30-percent reduction in development time and manufacturing cost of cooled airfoils) and engine testing. The products of this element will be incorporated into the next generation of very-high-bypass ratio commercial engines and derivatives or enhancements of engines currently in service.

Finally, the Technology Integration element allows for a full understanding of the relative payoff of emerging technologies. This element provides a systems analysis capability which is essential in the development of a credible assessment of the impact of NASA aeronautics technologies on tlie U. S. industry. The goal of this element is to provide credible assessments of the impact of alternative emerging civil aeronautics technologies on the integrated aviation system. Such assessments will assist in planning and managing the AST program, as well as assist customers of AST technologies in understanding the impact and potential on an integrated aircraft and system. There are two objectives of this element. First, to better assess aeronautics technologies, an aviation system analysis capability (ASAC) linking the multidisciplinary and multifaceted aspects of the global aviation system will be developed. This is significantly beyond the capabilities of any single analytical goal available today, though many of its constituent components exist in specialized areas, such as air traffic management. Second, technology integration studies to investigate issues of broad significance to the AST program will be an ongoing activity, augmented in capability as additional methodologies become available. On a cost/benefit basis, the studies provide assessments of the relative merits of alternative programmatic approaches, technologies and program guidelines. The ongoing subsonic program and other AST elements must be supported with studies to assess the integrated benefits of results and to assist in planning their evolution.

General Aviation

General Aviation (funded under both the Safety and the Reduced Seat Cost elements) in the U. S. represents approxiniately 45 percent of the nine billion air miles flown by all civil aviation annually. However, annual U. S. production of general aviation aircraft has fallen to approximately five percent of the 1978 level. In cooperation with U. S. industry, through a 50/50 cost-share venture, NASA seeks to support revitalization of U. S. general aviation through development and deployment of advanced technologies for enhanced small aircraft transportation system capabilities. Improvements in affordability, utility, ease-of-use, arid reliability of the next generation of general aviation aircraft for business and personal transportation result from the application of these technologies. In the process, small aircraft transportation becomes available to more people, more of the time, and to more places throughout the infrastructure of small communities and rural areas. The scope of the element includes single-pilot, light, fixed-wing personal transportation aircraft, as well as business and commuter aircraft and rotorcraft having the same functional and technology requirements. Achieving the goal supports the expansion of the nation's economy by better serving the vast infrastructure of over 5,100 public-use and over 18,000 non-public general aviation airports.

General Aviation technologies are targeted to improve the safety, utility, ease-of-use and reliability of the next generation of general aviation aircraft for business and personal transportation. This element is funded under both the Safety and the Reduced Seat Cost elements. The safety related technologies include icing protection and human interface with flat panel displays. Technologies related to reducing the seat cost of general aviation aircraft include integrated design and manufacturing, advanced materials process and design, quality control nondestructive evaluation, integrated cockpit systems, navigation and communications, and advanced software capabilities. By maintaining safe, all-weather flying skills, expanded use of general aviation is expected to fuel expansion of the national economy by bringing remote communities into the mainstream of U. S. commerce by using smaller local runways rather than major airports.

MEASURES OF PERFORMANCE

Safety

Complete field demos for tech transfer to industry Plan: September 1998	Develop specialized engineering analysis tools to quantitatively evaluate inspection findings by computing remaining life, inspection intervals, and the residual strength of structural repairs, field demonstrations of NDE prototype instruments to illustrate technology utilization and conduct focused workshops to transfer all technology to the instrument manufacturing industrial community.

Environment

Noise Reduction: Validate concepts for 3-decibel jet and fan noise reduction relative to 1992 technology. Plan: September 1996 Actual: December 1996	Experimental verification through high-fidelity, scale model, 1.5-6 bypass ratio engine simulator concepts (e.g. optimized fan/stator geometries, improved nacelle duct treatment). Tests show potential to achieve three dBA fan and jet noise reduction. Significant reduction in fan noise demonstrated due to fan/stator geometry. Jet noise reduction was achieved through use of improved jet exhaust design tool. In addition, 25 percent liner improvement achieved through incremental improvements in multi-step liner design process. First quarter FY 1996 furlough caused a three-month delay in testing models in the Lewis Research Center 9x 15 tunnel due to wind tunnel scheduling.
Propulsion: Evaluate flametube combustor concepts Plan: March 1998	Advanced tube combustor concepts will be evaluated for their potential to reduce NOx by conducting flametube experimental tests at 60 atmospheres to simulate engine combustor operating conditions.
Demonstrate flight-applicable active noise control on large engine. Plan: December 1998	Demonstrate that active noise reduction technology is sufficiently mature for flight application on a large engine.

Demonstrate reduction of future engine emissions of NOx by 50 percent for large engines.	Denionstrate in a full annular combustor rig a low eniission combustor which meets the 50 percent NOx goals for large engines.
Plan: September 1999	

Capacity

Terminal Area Productivity: Flight test new cockpit systems.	Flight tests demonstrated satisfactory integration of the technologies supporting cockpit systems for landing, roll out and taxi.
Plan: September 1997 Actual: September 1997	Flight tests were conducted at Atlanta International Airport in which the Dynamic Runway Operations Monitor (DROM), Roll-Out-Turn-Off (ROTO) guidance, and Taxiway Navigation and Situational Awareness (T-NASA) head-up and planform display technologies were successfully shown to work synergistically and improve pilot capabilities for ground operations.
Advanced Air Transportation Technology: Complete field study of conflict probe.	A Non-Advocate Review replaced this milestone with this more pertinent one: Coniplete the set of National Airspace System operations concepts and the identification of the products to support the most likely future airspace scenario.
Plan: September 1997 Actual: September 1997	A concept of operations was developed to assure that the program is coordinated with FAA and Industry plans. AATT products were assessed to assure that they are appropriately addressing the requirements of the concept of operations. This Operational Concept and assessment of the products was completed in September. 1997, approved by an ASTTAC ARTS for ATM in October 1997, and approved by a NASA Independent Review in November, 1997.
Terminal Area Productivity: Transport system research vehicle (TSRV) ready to perform terminal area research.	Provide flight research capability for support of TAP technology development and demonstration. (Milestone date was incorrectly reported **in** FY 1998 narrative.)
Plan: April 1998 Correction: September 1998	
Full-span civil tiltrotor wind tunnel testing.	Complete full-span wind-tunnel testing of civil tiltrotor model to demonstrate low noise rotor concepts and acoustic code validation with wake and fuselage effects.
Plan: Septeniber 1999	

Reduced Seat Cost

Integrated Wing Design: Mid-term assessment of impact on aircraft DO and design cycle time compared to the baseline configuration.

Plan: September 1997
Actual: October 1997

Evaluation of technology improvements will result in at least one-percent improvement in aircraft DO and 20-percent improvement in aero design cycle time.

The mid-term assessment showed the potential to obtain a one-percent reduction in aircraft DO and a 15-percent reduction in aerodynamic design cycle time primarily from wing design arid propulsion/airframe interaction technologies developed by NASA in this element and in use by industry today.

Technology Integration: Release first-generation aviation system analysis capability.

Plan: January 1997
Actual: February 1997

Deliver a computerized process that provides AST management with easy access to analysis and data bases for identifying potential benefits of AST technologies.

An initial Web-based aviation analysis system with integrated model architecture and advanced system models and databases was delivered which will provide the assessment of potential technology benefits.

Conduct semispan wing test.

Plan: September 1998

In-house semispan wing test conducted lo demonstrate manufacturing and assembly feasibility, verification of analysis methodology, and preliminary cost and weight reduction data.

Final milestone for this element.

Demonstrate improved turbomachinery design.

Plan: September 1999

Initial turbomachinery design tools and methods available for validation and application to next generation of highly fuel efficient, environniently compatible, maintainable and reliable engine systems.

Final milestone for this element.

General Aviation

General Aviation: Define general aviation transportation system operational, functional and performance requirements.

Plan: February 1997
Actual: June 1997

Define and publish small-aircraft transportation system requirements for users, aircraft and infrastructure.

Published and distributed the systems control, operational requirements and technical requirements documents. The complexity of coordinating with government, industry and universities partners resulted in a delay in publishing these codependent documents.

Complete market assessments

Plan: March 1999

Complete market assessments of current and latent market and assess domestic and international benefits.

ACCOMPLISHMENTS AND PLANS

FY 1997

In **Safety,** field testing was conducted, signal processing techniques were refined for all prototype nondestructive evaluation (NDE) systems and the methodology to analytically predict onset of widespread fatigue damage, fatigue crack growth, and residual strength of fuselage structure was verified.

In **Environment,** concepts were validated for three-decibel (dB) fan/jet noise reduction and for improved nacelle duct treatment effectiveness by 25 percent relative to 1992 technology baseline. Fundamental flametube testing up to 50 atmospheres with advanced fuel injectors was also conducted which showed promise of achieving 70 percent reduction in oxides of nitrogen (NOx). The Subsonic Assessment Interim Report identified the impacts of the current subsonic fleet that are potentially significant; the current understanding of critical atmospheric processes and capability of predictive models are adequate only for qualitative assessment of aircraft effects in most areas: and substantial improvements are required in scientific understanding and model treatment of processes.

In **Capacity,** a set of National Airspace System operations concepts and the identification of the products to support the most likely future airspace scenarios were completed. Flight tests denionstrated successful integration of the technologies supporting cockpit systems for landing, roll-out and taxi. Civil tiltrotor flight evaluations were completed on low-noise terminal area operations and various noise reduction concepts were tested in our major wind tunnel facilities— thus building a database from which to choose more advanced operational techniques and rotor configurations for further analysis and testing.

In Reduced Seat Cost, an automated pressure sensitive paint system for use on low-speed production testing was demonstrated and computational fluid dynamics methods to design a pylon/nacelle was developed for an existing wing. The first generation of the ASAC was released, providing a system for understanding and evaluating the effect of advanced aviation technologies on the U. S. aviation system. Documentation of the preliminary design and requirements was completed for a full-scale composite wing, and a fabrication plan was established for a dry fiber stitched resin film infused composite wing.

In **General Aviation,** small aircraft transportation system operational, functional, and systems performance requirements (for users, aircraft, and infrastructure) have been defined based on industry, FAA, and user community inputs. Consensus was reached on using the NavRadio general aviation datalink architecture for a flight systems work package.

FY 1998

In **Safety,** the Aging Aircraft element of the AST program will be completed with the transfer of NDE prototype systems and structural integrity analysis methodology to the transport industry.

In **Environment,** engine cell testing will begin on previously developed flight-applicable active noise control concepts. Preparation work for testing advanced low NOx combustor concepts in sector rig tests will be continue. Atmospheric assessments will focus on the characterization of particles from aircraft engine emissions and development of a three-dimensional global atmospheric model will continue.

In **Capacity,** assessments of current airborne systems to support the possibilities of the FAA free flight concept will be completed. The aircraft vortex spacing system sensor subsystems and predictor rules will be tested. The advanced tiltrotor aeroacoustic code (TRAC) will be validated arid model scale wind tunnel testing of an isolated rotor model will be completed to determine the degree of noise reduction and performance level of several prototypes.

In **Reduced Seat Cost,** extended-use disk manufacturing will be demonstrated to reduce cost by extending disk life and maintenance intervals. The critical design review of the semispan composite wing and side-of-body joint will be conducted to ensure the test article will meet all strength, maintenance and cost requirements necessary to reduce wing cost by 20 percent and airline DOC by at least four percent. The ability to integrate the design of high-lift systems with the propulsion system will be demonstrated as one contribution to reducing design cycle time and cost.

In General Aviation, with the definition of system requirements in place, development will continue in the technology areas of ice protection, satellite navigation, flat-panel displays, small computers, expert systems, and digital data link communications. Additionally, assessments of U. S. and international general aviation markets will begin establishing the potential benefits of increased growth in general aviation.

FY 1999

In Environment, methodology to optimize take-off and landing flight tracks that will reduce community noise impact will be developed. Sector rig testing of low emission combustor concepts will be conducted which will meet the 50-percent NOx reduction goal for large engines. The third field test focusing on atmospheric observations will be conducted to further refine the global climate models.

In **Capacity,** the definition of an expanded operational evaluation of advanced air transportation technologies for application to complex airspace and systems evaluations to demonstrate the feasibility of distributing tasks between flight crews and ground controllers for safe air to air separation will be completed. A flight test will be conducted to denionstrate the Center-Terminal Radar Approach Control Automation System (CTAS)011 the ground and advanced FMS in the flight vehicles utilizing data-link capabilities to facilitate inforniation exchange between CTAS and flight management systeni (FMS). Full-span wind-tunnel testing will demonstrate low noise rotor concepts and acoustic code validation with wake and fuselage effects.

In FY 1999, efforts supporting the **Reduced Seat Cost** thrust will be completed. Improved turbomachinery design codes will be applied and validated to demonstrate increased capability (highly efficient, environmentally compatible and reliable) engine systems. Assembly of the semispan composite wing will be completed and a test readiness review will be conducted. A design niethod for integrating the aerodynamic design of the wing with the propulsion system will be validated and provided to industry. Following completion of evaluations of the earlier release, the operational version of the ASAC computer code, including aviation databases and economic and aviation system analysis models, will be released.

In **General Aviation,** assessments of current/latent general aviation markets, as well as the domestic and international benefits of general aviation aircraft, will be conducted.

Advanced Space
Transportation
Technology

SCIENCE. AERONAUTICS. AND TECHNOLOGY

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TRANSPORTATION TECHNOLOGY

ADVANCED SPACE TRANSPORTATION TECHNOLOGY

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
X-33 Advanced Technology Demonstrator	262.000	318.300	282.800
[Stennis Space Center Test Stand Modification CoF]	[2,300]	[3,700]	[..]
X-34 Technology Demonstration Program	20.500	26.700	39.000
Bantam/Low-Cost Upper Stages	19.800	36.000	1.500
Future-X Demonstration Program	--	--	17.000
Future Space Launch Studies	--	10.000	20.000
Advanced Space Transportation Program (ASTP)	34.400	26.100	28.300
Total	336.700	417.100	388.600

Distribution of Program Amount bv Installation	FY 1997	FY 1998	FY 1999
Johnson Space Center	2.827	12.400	7.600
Kennedy Space Center	302	600	--
Marshall Space Flight Center	275.279	328.400	312.0 0
Stennis Space Center	7.255	28.800	22.400
Ames Research Center	10.675	7.200	7.200
Dryden Flight Research Center	4.952	3.500	8.400
Langley Research Center	13.639	8.400	7.800
Lewis Research Center	5.299	8.100	5.100
Goddard Space Flight Center	2.466	--	--
Jet Propulsion Laboratory	8.456	8.300	3.000
Headquarters	5.550	11.400	14.900
Total	336.700	417.190	388.600

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 1999 ESTIMATES

PROGRAM SUMMARY

ADVANCED SPACE TRANSPORTATION TECHNOLOGY

PROGRAM GOALS

The goal of the Advanced Space Transportation Technology program is to develop and demonstrate new technologies aimed at revitalizing access to space. These new technologies are targeted to reduce launch costs dramatically over the next decade, to increase the safety and reliability of current and next generation launch vehicles, and to establish new technical capability for in-space transportation systems This will reduce the cost of NASA's science and exploration programs, improve the competitiveness of the U. S. commercial launch industry and enable new government and commercial endeavors.

STRATEGY FOR ACHIEVING GOALS

NASA's primary space transportation technology role is to develop and demonstrate pre-competitive, next-generation technology that will enable the commercial development of truly affordable and reliable access to space and space transfer. This in turn should enable the U. S. to recapture leadership in worldwide commercial space transportation in the early decades of the next century. Consistent with the National Space Transportation Policy, NASA, as a member of the national team, will develop technology for the next generation space transportation system, with a target of reducing launch and space transfer vehicle development and operations costs dramatically after the year 2000. NASA will also support DoD in developing and demonstrating technologies which support Evolved Expendable Launch Vehicle and Military Spaceplane objectives as well as participate in the government/industry Integrated High Payoff Rocket Propulsion Technology (IHPRPT) initiative.

Advanced Space Transportation Technology is divided into the Reusable Launch Vehicle (RLV), the Advanced Space Transportation Program (ASTP) and Future Space Launch Studies. Incorporating innovative partnerships with industry and academia, the RLV and ASTP programs will help provide information for the Future Space Launch Studies that will prepare the U. S. for key decisions regarding the future development of space transportation systems. The overall program will range from the exploratory research of high pay-off emerging technologies, to the flight demonstration of advanced technologies by X-Vehicles. Alliances with space transportation customers, including the Department of Defense (DoD), commercial, and NASA Enterprises, will define the requirements for technology investments.

NASA has an ongoing effort to develop a comprehensive space launch strategic plan outlining the Agency's space launch requirements, the current investments in launch vehicle technology development and operations, and the objectives, strategy, budget and key decisions that will enable a future space transportation architecture for NASA. Based on the results of the X-vehicle

BASIS OF FY 1999 FUNDING REQUIREMENT

COMMERCIAL TECHNOLOGY PROGRAM

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Technology Dissemination & Marketing...........................	5,700	5,700	5,600
Electronic Network..	600	900	1,500
Business Practices Implementation..................................	17,400	16,700	14,100
Metrics, Evaluation, & Policy..	1,700	1,500	1,600
Culture Change & Education...	400	400	400
Total Commercial Technology Program	25,800	25,200	23,200

PROGRAM GOALS

The commercial technology program goal is to share the harvest of NASA's technology programs with the U. S. industrial community. The goal encompasses the commercialization of technology developed in all the Agency's Enterprises, in past as well as current programs. The scope of the commercialization effort includes technologies created at NASA centers by civil servants and innovations from NASA contractors. The technology commercialization program assures that NASA's technology developments contribute to a significant improvement in the quality of American life and an increase in America's international competitiveness.

STRATEGY FOR ACHIEVING GOALS

NASA is continuing to implement a new way of doing business in the area of technology transfer. Changes in national R&D investment guidelines have elevated commercial technology transfer to a fundamental NASA mission. NASA's Agenda for Change, approved by Administrator Goldin in July 1994, is the agency's blueprint for achieving this mission. The Agenda for Change is organized into six sections, each reflecting an important aspect of this new way of doing business. The six sections are: Commercial Technology Policy; Commercial Technology Business Practices: Marketing NASA's Capabilities; Commercial Technology Metrics; Culture Change Through Training and Education; and the Commercial Technology Electronic Network. Each section implements components of the national and agency policies in order to reinvent the way that NASA transfers technology to and from the national economy.

ground and flight demonstrations, the National Space Transportation Policy calls for a decision on whether or not to pursue full scale developnient of an operational RLV. In preparation for that decision, NASA has set aside $760 million in a Future Space Launch budget line in the outyears for an end-of-decade decision on whether to pursue future launch vehicles that would lower NASA's launch costs.

Reusable Launch Vehicle (RLV)

The RLV program includes systems engineering and concept analysis, ground-based technology development, and a series of flight demonstrators (the DC-XA, the X-34 Technology Testbed Demonstrator, the X-33 Advanced Technology Demonstrator). In FY 1998 and FY 1999 the RLV program will consist of the X-33, X-34, and Future-X programs. Each part of these closely integrated programs contributes to validating key component technologies, proving that they can be integrated into a functional vehicle and demonstrating low cost operations in relevant flight environments. The DC-XA test vehicle demonstrated small-scale technologies in subsonic flight environments and paved the way for the more aggressive X-34 and X-33 programs.

The X-34 program will demonstrate technologies necessary for a reusable vehicle, but will not be a commercially viable vehicle itself. It will be a rocket-powered, Mach-8-capable flight demonstrator test bed to close the performance gap between the subsonic DC-XA and the Mach 13+ X-33. The X-34 objective is to enhance U. S. commercial space launch competitiveness through the development and demonstration of key technologies applicable to future, low-cost reusable launch vehicles. The X-34, flying in early FY 1999, will demonstrate flexible integration capability, high flight rate (25 flights per year), autonomous flight operations, safe abort capability, arid a recurring flight cost of $500,000 or less. The X-34 program is procuring two flight articles, in keeping with the usual practice in X-vehicle programs, to ensure that the program meets its objectives without constraining the aggressiveness of the demonstration effort.

The 30-month, fixed-price X-34 contract will be conducted by Orbital Sciences Corp. of Dulles, Virginia. Government involvement will include NASA's Arnes, Langley, Dryden, Marshall, Kennedy and White Sands complexes and Holloman Air Force Base covering primary propulsion development activity, thermal protection system integration, wind tunnel support, and testing and flight operations.

After completion of the first flight series (the basic contract includes two flights), the X-34 program is planning a second phase for additional flight testing of up to 25 flights in one year. These flights will demonstrate key embedded technologies and systems operations, as well as additional technology experiments and test articles from the RLV and Advanced Space Transportation programs. X-34 modifications and experiments will benefit from being comparatively small, thereby lowering the expense and risk of demonstrating the technologies, and making their integration into the vehicle less costly. The low-cost X-34 demonstrator will increase the scope arid aggressiveness of flight demonstrations, thus increasing the return to the RLV program.

The X-33 objective is to demonstrate technologies and operations concepts that could reduce space transportation costs to one tenth of their current level, thereby freeing up billions of dollars for technology, science and exploration. As directed in the National Space Transportation Policy, the X-33 program includes two major decision points. The first, whether or not to proceed with Phase II, was completed in July 1996 and was made based on specific programmatic, business planning, and technical criteria which had previously been agreed upon by NASA, the Office of Management and Budget and the Office of Science and Technology Policy. NASA selected the Lockheed Martin Skunkworks to lead an industry team to develop and fly the X-33 in the last quarter of FY 99. The second decision will be made after X-33 ground and flight tests, when government and industry will consider whether full-scale development of an operational RLV (Phase III) should be pursued, At that point, if the industry partners and investment community are not satisfied that the technological risk is low enough to proceed to full-scale development, NASA will pursue other options, including continued RLV technology work to accomplish further risk reduction. For example, the X-33 may require technology enhancements, or a follow-on vehicle to the X-33 may be needed to prove ultimate feasibility. The funding for this continued work is in the Future-X budget line.

NASA is utilizing an innovative management strategy for the X-33 program, based on industry-led cooperative agreements. As a result of industry's leadership of the program, the participants are not playing traditional roles, with government overseeing and directing the work of the industry contractors. Instead, government participants are acting as partners and subcontractors, performing tasks which offer the most effective means to accomplish the tasks. The government participants report costs and manpower to the industry team leader as would any other subcontractor. Every NASA center except the Goddard Space Flight Center has a negotiated role on the X-33 program. The industry-led cooperative arrangement allows a much leaner management structure, lower program overhead costs, and increased management efficiency.

The X-33 is an integrated technology effort to flight-demonstrate key technologies, and deliver advancements in: 1) propulsion, including a prototype engine; 2) lighter, reusable cryogenic tanks; ***3)*** application of New Millennium microelectronics for vastly improved reliability and vehicle health management; 4) advanced Thermal Protection Systems to reduce maintenance; and 5) ground and flight operations techniques that will substantially reduce operations costs for an RLV. X-33 will combine its results with the successes of the DC-XA, X-34 and complementary ground technology advances to reduce the technical risk of full-scale development of an operational RLV. The X-33 test vehicle will fly 13-15 times the speed of sound and will test the boundaries of current technology. Together, the DC-XA , X-34, and X-33 will provide an unprecedented 50-75 flight tests of key technology demonstration prior to a full-scale development decision.

Programmatic and business plans for an operational commercial RLV, expressed in innovative industry-developed and -led business plans, will receive equal consideration with technology demonstrations in future decisions on developing an operational launch vehicle. These plans will address policy and legislative issues and private financing options and inform Future Space Launch Studies. It is envisioned that private industry will have a primary role in the funding, development, and operation of a next-generation launch system. Therefore, business venture plans are as critical to the RLV program as any technical advancements made on the experimental vehicles.

The Focused Program in Small Payload-Class Boosters is investing in innovative technologies for low-cost manufacturing and systems engineering which will lead to space transportation hardware that does not require the highly specialized, labor-intensive manufacturing and operation of current space transportation systems. For example, the current price of an existing, small-launcher liquid oxygen/kerosene propulsion system is $3-5 million. This program has initiated efforts which will drive the costs of such engine systems down to $300-400 thousand. This key propulsion technology effort will provide a flight engine for the X-34 in the first quarter of FY 1999. The Small Payload-Class Focused Program has selected seven companies to perform eleven component development activities as a **part** of the Bantam System Technology Project - Phase I. These technology activities will run in parallel with the X-34 engine development and will be focused on operationally efficient, low-cost hardware at the component and subsystem level. Over the last few years, NASA has expended significant resources to reduce the size, cost and development time associated with science payloads. In addition, the university science community has identified the desire to begin launching 4-6 university explorer-class (UNEX) missions per year after the turn of the century. These payloads will incorporate important emerging technologies, cost only a few million dollars to develop, and will rejuvenate the university science community; however, they can only be accomplished with the availability of a low-cost launch system, In order to meet this emerging need, NASA solicited industry proposals (NRA 8- 19, Bantam System Technology Project - Phase II) for a technology development and demonstration program that will enable the low-cost launch goals. In Cycle I, Area 1 of the NRA, four low-recurring-cost concepts were selected for study for six months. Under Cycle II, Area 1, original plans were for the selection of up to two parallel technology demonstration programs leading to flight demonstration of the selected low-cost technologies in 2000. Current plans are to have a conference in January of 1998 of launch service providers, users, and other interested parties to determine a preferred program structure. In Cycle I, Area 2, five areas of low-cost technology ground demonstrations will be pursued to further reduce recurring launch costs. In Cycle I, Area 3, one contractor was selected to provide the flight demonstration of a low-cost upper stage in conjunction with the Air Force. While the UNEX-class boosters represent the first application of these important technologies, it is expected that the advancements will apply to other low-cost reusable liquid booster concepts (e.g., flyback boosters).

As part of NASA's core mission to advance the state-of-the-art in aeronautics and space transportation, the Agency will continue to develop and denionstrate advanced technologies through the use of experimental flight vehicles. The primary objective of this "Future X" program is to flight demonstrate technologies which can dramatically reduce the cost and increase the reliability of reusable space launch and orbital transportation systems. It is envisioned that Future-X demonstrations will build on ASTP technologies under a two-tiered approach, consisting of small-scale flight demonstrations carried out within a one to two year time period (Pathfinder class), and larger integrated systems-level flight demonstrators occurring as required (Trailblazer class). Pathfinder class systems would demonstrate cutting edge technologies with high payoff potential and cost between $1M and $100M. Trailblazers will respond to the outcome of the X-33 and X-34 programs and will either provide complenientary technology to the commercially funded full-scale development of an operational RLV or continue development and demonstration of technology for government and commercial users. Trailblazer integrated systems demonstrations will be at a scale such that eventual operational systems costs, producibility, operability, and performance could be validated and incorporated into the transportation elements with minimum development time and uncertainties, NASA will begin funding for new Pathfinder-class vehicles in FY 1999 under the Future-X program.

The X-33 program is funding the capital investment in the A- 1 and B-2 test stands at the Stennis Space Center. Refurbishment of the A-1 test stand at Stennis in FY 1997 ($2.3 million) will enable testing of X-33 engines. The B-2 test stand is to be refurbished with FY 1998 appropriations ($3.7 million).

Advanced Space Transportation Program (ASTP)

Continuing the revolutionary advancements in space access that we expect from the RLV Technology Program, ASTP is developing key technologies to dramatically reduce space transportation costs across the mission spectrum. The ASTP will focus on technological advances with the potential to reduce costs beyond RLV goals as well as technology development required to support NASA strategic needs not addressed by RLV. ASTP aims at a cost-to-orbit measured in hundreds, not thousands, of dollars per pound.

The ASTP prograni includes a base of Core Technology investments, as well as technology investments unique to various Focused Programs. The ASTP Core Technology Program includes investments in Airframe Systems, Propulsion Systems, and long-term Space Transportation Research. Current efforts under ASTP Focused Programs include investments in Small Payload-Class Boosters, Hybrid Propulsion, Low-Cost Upper Stages, and RLV Risk Mitigation, In future years, other possible Focused Programs include Air-Augmented Propulsion and Exploration. Each element of the ASTP program addresses a recognized need for near- and long-term reductions in space transportation costs by taking bold steps forward in innovative technologies and vehicle configurations. An inter-center process has been put in place to prioritize ASTP technology investments based on their system payoff in terms of improvements in mission capability, cost, reliability, operability, responsiveness, and safety. The goals, objectives, and progress of the ASTP and RLV programs will be evaluated on a yearly basis by a panel of nationally recognized experts to ensure that program content is consistent with government and industry priorities.

The Core Technology Propulsion Systems Program is pursuing the maturation of highly reusable technologies beyond X-33 for reusable launch vehicles. The primary goal is to reduce the payload transportation cost to Low-Earth Orbit (LEO)by approximately a factor of 100 over today's costs. The technologies currently being pursued focus on air-breathing rocket-based combined cycles (RBCC). Future technology investments will focus on advanced materials to reduce weight and improve engine life, advanced nozzles to improve performance, and turbomachinary technologies to improve reliability and engine life. The aim is to mature propulsion technologies through ground testing and analyses to the point where they can be considered for a Future X-vehicle flight evaluation. Four RBCC concepts have been selected for preliminary proof of concept ground demonstration in FY 1998. These denionstralions will lead to a decision in FY 1999 on whether or not to proceed with further development of a flight demonstration project. Propulsion technologies will be addressed in partnership with NASA Aeronautics Centers, DoD and industry to assure maximum synergy between aeronautics research and the systems design and application to space launch.

The Core Technology Airframe Systems Program is pursuing the maturation of highly reusable airframe and structures technologies beyond X-33 for reusable launch vehicles. As with the propulsion technologies, the primary goal is to reduce the payload transportation cost to LEO by approximately a factor of 100 over today's costs. Airframe Systems technologies include structures and materials, cryogenic tanks, thernial protection systems (TPS), avionics/operations, and system analysis, design and integration. Technology investments are just beginning in: advanced composites and refractory composite hot structures development; technologies for both structure and cryotankage joints; ultra-high temperature ceramic thermal protection materials; instrunientation for vehicle health monitoring; and highly reliable avionics systems. The aim is to mature these technologies through ground testing and analyses to the point where they can be considered for a Future X-vehicle flight evaluation. Airframe Systems technologies will be addressed in partnership with NASA Aeronautics Centers, DoD and industry to assure maximum synergy between aeronautics research and the systems design and application to space launch.

The Core Technology Space Transportation Research activity focuses on advanced concepts for enabling breakthroughs in space transportation via small, critical technology experiments and breadboard validations. This effort provides the basic research function of the ASTP program and relies on partnerships with industry, universities, other agencies and NASA centers to identify longer term technologies with tremendous promise for performance improvement and cost reduction. Areas of interest include magnetic levitation for launch augmentation, pulse detonation engines, high-energy propellants, and advanced propulsion concepts and materials which hold promise for enabling exiting new missions that are beyond the realm of present technological capability.

The Focused Program in Hybrid Propulsion is being conducted under a Cooperative Agreement between NASA, DoD and U. S. industry, with the objective of demonstrating hybrid (solid fuel, liquid oxidizer) propulsion technology to enable U. S. industry to commercialize hybrid boosters for space launch operations. Hybrid motors offer potential for safer, lower cost, and environmentally friendlier boosters for U. S. launch providers. This resource-shared (experts, facilities and dollars) and jointly managed program will demonstrate full-size, flight-like boosters on a schedule suitable for application on operational launch systems early in the 21st century. The program will accomplish ground test firings of a series of 250,000-pound thrust motors designed lo allow rapid development of flight hardware with minimum risk.

The Focused Program in RLV Risk Mitigation will pursue investments in airframe systems and propulsion technologies consistent with goals of the X-33 and X-34 programs to reduce the cost of access to space to $1000/lb shortly after the turn of the century by enabling the full-scale development of an operational RLV. The RLV Risk Mitigation effort will pursue alternative or back-up technology approaches to those currently in the X-33 and X-34 programs, as well as new technology approaches that have been discovered since the fixed-funding X-33 and X-34 programs were begun. Technology investments are just beginning in conformal non-autoclave-cured composite cryotanks, light-weight advanced metallic and ceramic thermal protection systems, and light-weight rocket engine materials/components.

The Focused Program in Low-Cost Upper Stages will achieve major advances in high-performance in-space transportation systems. These systems will cut launch costs by reducing the mass to orbit of space transfer propulsion systems. Today, upper stage propellants represent 70% of the total mass of the combined upper stage and spacecraft payload. The program supports the design and ground testing of the NASA Solar electric propulsion Technology Application Readiness (NSTAR) ion engine to be flown on the New Millennium DS-1 spacecraft in 1998. NSTAR will validate ion propulsion for future robotic planetary missions. The project will also support technology work in the area of advanced electric and thermal propulsion systems for earth orbit and planetary transfer, technologies for atmosphere-assisted entry for planetary missions and earth-orbit return, cryogenic fluid management for orbit transfer and exploration missions, and non-conventional orbit transfer systems, such as electrodynamic tethers.

The 1994 National Space Transportation Policy (NSTC-PD4) calls for an end-of-the-decade decision on the development of an operational launch system to reduce NASA's launch costs. To support this decision, funding is provided in FY 1999-2000 for industry-led trade studies on a future NASA space transportation architecture. These studies will provide input to NASA's Space Transportation Council before the Council prepares a recommendation to the Administration on an appropriate approach. Separate efforts being undertaken, such as the Crew Rescue Vehicle (CRV) for Station, Future-X demonstration strategy, and possible business plans for X-33 Phase 111, would contribute to these studies. Placeholder funds are set aside in FY 2001-2003 to pursue existing, planned or new vehicles in response to the Administration's end-of-the-decade decision.

MEASURES OF PERFORMANCE

Reusable Launch Vehicle (RLV)

X-33 Vehicle Systetns Preliminary Design Review Plan: November 1996 Actual: November 1996	Systems preliminary design review was accomplished for the X-33 vehicle, the first key review milestone.
X-33 Environmental Impact Statement (EIS) Hearings Plan: November 1996 Actual: November 1996	Public Hearings as part of Environmental Impact Statement process are required to address X-33 launch and landing site environmental and overflight issues.
X-34 System Design Freeze Plan: May 1997 Actual: May 1997	Closed the vehicle design for production, validated readiness of the vehicle technologies, and defined schedule to first flight.
X-33 Critical Design Review Plan: July 1997 Actual: October 1997	The second key review milestone, which closed the vehicle design for production , validated readiness of the vehicle technologies, and defined schedule to first flight. Delayed to solve issues of weight growth and flight stability and controllability.
X-33 EIS Record of Decision Plan: October 1997 Actual: November 1997	EIS Record of Decision allowed launch site construction to begin. Mitigated several flight safety and environmental issues.
LO2 Tank Delivery Plan: December 1997 Actual: January 1998	Completes design, manufacture, test and delivery.
LH2 Tank Delivery Plan: December 1997 Revised: June 1998	Completes design, manufacture, test and delivery. Delayed because of tank redesign activities and issues with main joint fabrication/testing.
First Aerospike Engine Test Plan: February 1998 Revised: March 1998	First complete J2-Aerospike test to support first flight unit engine scheduled for delivery in July 1998.

X-33 Thermal Protection System Delivery Plan: April 1998 Revised: August 1998	Delivery of complete Thermal Protection System for X-33 flight demonstrator, Delayed due to LH2 tank delay,
X-34 Engine Delivery Plan: June 1998 Revised: December 1998	Completes design, manufacture, test and delivery. Delayed due to design integration difficulty and test failure.
X-33 Vehicle Rollout Plan: September 1998 Revised: May 1999	X-33 flight demonstrator vehicle rollout enabling final checkout. Delayed due to LH2 tank delay.
X-34 First Flight Plan: November 1998 Revised: March 1999	The flight test program will fly at speeds greater than Mach 8. Delayed due to design integration difficulty and engine delay.
X-33 First Flight Plan: March 1999 Revised: July 1999	The flight test program, based at Dryden Flight Research Center, will fly at speeds greater than Mach **13.** Delayed due to LH2 tank delay.

Advanced Space Transportation Program (ASTP)

Authority to Proceed on Bantam Cycle I proposal responses Plan: September 1996 Actual: January 1997	One contract awarded October 1996. Three contracts awarded December 1996 Three contracts awarded January 1997 Administrative delays.
Launch first hybrid sounding rocket from Wallops Flight Facility Plan: December 1996 Actual: December 1996	Represents the first in a series of hybrid rocket flights conducted or sponsored by Environmental Aeroscience Corporation (EAC).Fixed-price milestone payment depended on flight occurring on schedule.
Ground Test First Hybrid 250K Motor Plan: 2nd Qtr FY 1997 Revised: 2nd Qtr FY 1998	Ready for test, but test facility scheduling conflict exists.

NSTAR 8000 Hour Ground Test Completion Plan: July 1997 Actual: September 1997	Demonstrate life of NSTAR Engine consistent with duty cycle on New Millennium Deep Space 1.
Begin Bantam Cycle I contracts Plan: July 1997 Actual: December 1997	Four contractors begin detailed system studies of low-cost vehicle concepts and enabling technologies. Delayed due to protest by a losing proposer.
NSTAR delivery for DS-1 launch Plan: August 1997 Revised: January 1998	Delivery of flight hardware will ensure adequate time for checkout and integration into the New Millennium spacecraft. All hardware delivered except flight thruster, which experienced test and manufacturing delays. No adverse effect on Deep Space 1.
RBCC component-level test completion (Mach 0-4). Plan: December 1997 Revised: May 1998	Ground test of critical low-speed RBCC technologies such as inlet design and low-speed air augmentation. Injector, inlet, and ignition system test complete. Thruster and low-speed air augmentation test delayed due to a test failure and scheduling difficulties.
Begin mission profile testing of NSTAR engine. Plan: March 1998	Test back-up flight hardware, gather and analyze flight data, and resolve any unforeseen flight anomalies.
Deliver X-34 test flight engine to **X-34** vehicle. Plan: June 1998 Revised: December 1998	Completes design, manufacture, test and delivery. Delayed due to design integration difficulty and test failure.
Complete integrated RBCC engine testing. Plan: August 1998	Integrated engine testing essential to predict propulsion system perforniance.
Complete 500-hour test of 10 kW Hall electric thruster Plan: June 1999	First demonstration/validation of high-power electric thruster
Complete design of flight-weight RBCC engine Plan: September 1999	Integrated performance/weight model of operational RBCC vehicle. Could lead to flight-weight engine development if justified by system payoff.

ACCOMPLISHMENTS AND PLANS

Reusable Launch Vehicle (RLV)

FY 1997 has been an important year for the X-34 as many key milestones were successfully passed. The project team froze the vehicle outer mold lines early in the year and completed the final scheduled series of wind tunnel tests. The preliminary design review and critical design reviews of the main propulsion system have been completed. The systems requirements review and system design freeze for the X-34 vehicle and associated reviews were completed in anticipation of first flight in the second quarter of FY 1999. In addition, major portions of the X-34 vehicle fuselage are under construction at Orbital Sciences' Dulles facility.

The X-33 program continued to make major progress on a number of fronts in FY 1997 in a very fast-paced development effort. The X-33 team completed a successful Preliminary Design Review only four months after being selected for the program. The liquid oxygen tank for the X-33 flight vehicle was completed and insulation and instrumentation are being installed to begin proof testing. The vehicle outer mold lines have been frozen and over 3,700 hours of wind tunnel testing completed. The design of the liquid hydrogen tank is complete and the lobes are under fabrication. Successful multi-cell hot-fire testing of the linear aerospike engine was carried out and major engine components are being constructed. Over 70 percent of the thermal protection system design is complete and major elements are under procurement and test. The draft Environmental Impact Statement was released and all public hearings completed. X-33 vehicle weight growth and aerodynamic control issues have also been successfully brought under control after extensive proactive reviews. The lessons learned on the X-33 program during the first 18 months are already having a beneficial effect on the design of an operational RLV, with the knowledge gained being applied to nearly every vehicle subsystem, including cryogenic tank design, aerodynamic design, TPS attachment techniques, and propulsion system design and integration. The result will be a substantially more mature, lower risk, higher performance RLV design at the end of the decade.

In FY 1997, the Focused Program in Small Payload-Class Boosters successfully demonstrated the Fastrac 60K Engine Thrust Chamber Assembly (TCA) at flight pressure (630 psi). This TCA costs around $100,000 compared to the $1,200,000 typical of this size LOX/RP-1 TCA. The Fastrac 60K Engine Gas Generator (GG) was also successfully tested at flight conditions. This component is estimated to cost $20,000 compared to the $360,000 typical of traditional GG's available today. The Fastrac engine system has completed the Critical Design Review (CDR) and turbomachinery, brackets, lines and ducts are in fabrication. Industry briefings were also conducted that resulted in the solicitation of NRA 8-19, Bantam System Technology Project. In Cycle I, Area 1, four contractors were selected to define and develop low-recurring-cost technologies with the objective of enabling initial commercial launch services in CY 2001, pending the results of a conference in January 1998 of launch service providers, users, and other interested parties to determine a preferred program structure. In Cycle I, Area 2, five component/system/operational technologies were also selected for development to further reduce launch costs. In Cycle I, Area 3, one contractor was selected to provide the flight demonstration of a low-cost upper stage that supports mission profiles characteristic of military space planes and commercial reusable launch vehicles.

Funding includes $2.3M in CoF funds for test stand modifications at the Stennis Space Center. These niodifications are required to allow testing of X-33 development and flight engines.

The X-34 effort in FY 1998 will primarily be focused on final airframe integration, technology experiment development, pre-flight testing and final engine delivery and checkout. The basic X-34 contract will largely be completed, with the exception of the first two flight tests which will be conducted in the second quarter of FY 1999. Up to 25 flights per year will be performed under an option to the contract in FY 1999 after completion of the basic contact.

X-33 1998 program activities will continue efforts of FY 1997 and focus on flight vehicle design and development and a comprehensive ground test prograni emphasizing full-scale engine technology development and lightweight composite hydrogen and oxygen tanks. Early in FY 1998, the formal Record of Decision for the Environmental Impact Statement was completed, and groundbreaking for the launch site construction has begun, The Critical Design Review for the X-33 flight vehicle successfully took place at the beginning of FY 1998. This was a very critical milestone in the program to verify the feasibility of the integrated design prior to major hardware construction and integration. Later in the year, X-33 engine testing will begin, the liquid hydrogen tanks will be delivered, and the majority of the vehicle structure will be integrated. RLV efforts will also include Venturestar System Requirements Review. A business plan detailing efforts required to support private sector and government investment options for the Phase III decision will be completed to inform the Future Space Launch Studies and the Administration's end-of-decade decision on whether to pursue an operational launch system to reduce NASA's launch costs.

In FY 1998, the Focused Program in Small Payload-Class Boosters will include initiation of engine testing and engine delivery to the X-34 project. FY 1998 funding also supports extensive component testing of technologies developed in FY 97-98, with the intent being to upgrade the X-34 engine using these components. The concepts of the four Cycle I, Area 1 proposals will be matured to approximately the PDR level. Planned activities under Cycle II of the NRA 8-19 are currently on hold, pending the results of a conference in January 1998 of launch service providers, users, and other interested parties to detemiine a preferred program structure. Concurrence on a final plan will be obtained from the Administration before any Cycle II funds are spent.

Funding includes $3.7M in CoF funds for test stand modifications at the Stennis Space Center. These modifications are required to allow testing of future space transportation development and flight engines.

FY 1999 will mark the beginning of the X-34 flight research program. The year will begin with a Flight Readiness Review for the integrated X-34 and L-1011 carrier vehicle. This will be followed by unpowered and powered flights. The basic X-34 contract will be completed after the first two flight tests. The funding provides for up to 25 flights per year under an option to the contract in FY 1999 after completion of the basic contact.

FY 1999 will also mark the beginning of the X-33 flight research program, which will carry over into FY 2000. The X-33 flight engine and thermal protection systems will be delivered and integrated with the vehicle. Final software testing will be complete, followed by X-33 vehicle roll-out. A Flight Readiness Firing and Flight Readiness Review will be completed, followed by first flight by the end of FY 1999. Launch site facilities and ground support equipment will be in place, and landing site preparations will be complete. RLV efforts will also include Venturestar System Design Review, testing of major full-scale engine components and completion of large-scale hydrogen and oxygen tanks for 100-cycle ground testing. Final decisions will be made concerning RLV financing methods in preparation for a decision at the end of FY 1999 on whether to go ahead with Phase III VentureStar development. This decision will be informed by the Future Space Launch Studies and contingent on the Administration's end-of-the-decade decision on whether to pursue an operational launch system to reduce NASA's launch costs.

In FY 1999, most activities that occur under the Focused Program in Small Payload-Class Boosters will depend on the results of a conference, in January 1998, of launch service providers, users, and other interested parties to determine a preferred program structure. Cycle II options include full-scale development of a technology demonstrator vehicle, ground-based technology demonstrations (including Fastrac upgrades), or establishment of incentives through launch vouchers or prizes. Cycle II funding, if any, will depend on Administration concurrence.

In FY 1999, the Future-X program will initiate one or more of the small Pathfinder class of flight demonstrations. Candidates include but are not limited to an ultra-high temperature leading edge thermal protection system demonstration, an atmospheric aeroassist technology experiment, a hypersonic flight test of a rocket-based combined cycle propulsion system, or demonstration of a high-specific-impulse orbital transfer propulsion system. Planning will continue with DoD for potential cooperation on a military spaceplane denionstration vehicle, as well as with industry for innovative X-vehicle demonstrations of technologies that could be utilized in commercial launch systems.

Advanced Space Transportation Program (ASTP)

In FY 1997, extensive planning has been under way for all elements of the ASTP programs. Integrated Planning Teams, coniprised of NASA center personnel, DoD and industry representatives, have developed extensive plans and technology development roadniaps for advanced airframe and cryogenic tank structures and materials, vehicle thermal protection systems, propulsion, and avionics/operations. Propulsion technology development plans have been coordinated and integrated into the government/industry Integrated High Performance Rocket Propulsion Technology (IHPRPT)initiative. Advanced launch vehicle systems definition studies have continued to identify promising concepts and technologies. NASA has initiated an ongoing effort to develop a comprehensive space launch strategic plan outlining the Agency's space launch requirements, the current investments in launch vehicle technology development and operations, and the objectives, strategy, budget and key decisions that will enable a future space transportation architecture for NASA.

In FY 1997, under the Core Technology Propulsion Systems program, the RBCC contractors completed their individual concept definition reviews and designs of the ground test hardware. Testing of RBCC critical component technologies (injectors, ignition systems, and inlets) was successfully completed.

Under the Core Technology Airframe Systems program, efforts have been initiated to develop technology plans for advanced structures and materials, cryogenic tanks, TPS, and avionics/operations to support the strategies of the NASA's Advanced Space Transportation Strategic Plan. An advanced TPS flight experiment (SHARP)was conducted to validate a new ultra-high temperature ceramics material that could enable sharp leading edges for reusable launch vehicles.

In the Core Technology Space Transportation Research program, feasibility issues associated with revolutionary propulsion concepts continued to be evaluated at MSFC and JPL. The antimatter-triggered fusion research has continued to show progress, with the development of the world's first portable Penning trap for the storage and transport of antiprotons. Feasibility evaluation of micro-niachined ion propulsion for micro-spacecraft was initiated. Multiple contracts were awarded under a NASA Research Announcement (NRA) to investigate the engineering feasibility of a pulse detonation rocket engine and magnetic levitation for launch assist.

The Focused Program in Hybrid Propulsion completed four sounding rocket flight demonstrations and successfully recovered the fourth test vehicle for analysis. This completes most of the smaller component development testing and database generation. Hardware for the first 250K-pound thrust test motors is being installed in the test facility at MSFC.

Planning efforts were initiated under the Focused Program in RLV Risk Mitigation to pursue investments in airframe systems and propulsion technologies consistent with goals of the X-33 and X-34 programs to reduce the cost of access to space to $1000/lb shortly after the turn of the century by enabling the full-scale development of an operational RLV. Plans were developed to pursue alternative or back-up technology approaches to those currently in the X-33 and X-34 programs as well as new technology approaches that have been discovered since the fixed-funding X-33 and X-34 programs were begun.

The Focused Program in Low-Cost Upper Stages continued to demonstrate the life and performance of the NSTAR system on the ground with the completion of the 8000-hour endurance test. In July 1997, the NSTAR bread board system was successfully tested with a DS-1 engineering model to verify interfaces. The NSTAR flight thruster was delivered in October for test, and the NSTAR flight system will be integrated with the New Millennium DS-1 spacecraft in January 1998. Launch is planned in July 1998. A request to manifest the solar thermal propulsion flight experiment (Shooting Star) has been has been submitted to the Space Shuttle Office for a planned FY 1999 flight. SBIR contracts are in place for the concentrator assembly and dual Rhenium and Hafnium Carbide Engine developments.

In FY 1997, Engineering Capability Development continued to fund utilization, maintenance. and productivity upgrades for the premiere national facilities at LaRC and ARC required to accomplish the goals of the Advanced Space Transportation programs.

In FY 1998, under the Core Technology Propulsion Systems program, Advanced Reusable Technologies contractors will complete RBCC thruster and injector/combustor testing. Testing of the three contracted integrated engine flowpaths (Mach = 0 -> 8) will also be completed. The performance data will be used to update vehicle concept models to determine whether additional facility testing is needed and whether to continue with a flight-weight engine design. Minor technology investments will begin in advanced materials to reduce weight and improve engine life, in advanced nozzles to improve performance, and in turbomachinary technologies to improve reliability and engine life.

The Core Technology Airframe Systems Program will begin limited investments in structures and materials, cryogenic tanks, thermal protection systems (TPS), avionics/operations, and system analysis, design and integration. Initial investments will focus on advanced composites and refractory composite hot structures development, technologies for joining both structure and cryotankage, ultra-high temperature ceramic3 thermal protection materials, instrumentation for vehicle health monitoring, and highly reliable avionics systems.

Under the Core Technology Space Transportation Research program, antiprotons will be trapped, cooled and transported from CERN in Switzerland to the Air Force Shiva-Star Facility for micro-fusion experiments. The project will also continue to assess the feasibility of a total-charge-transfer cathode for high-power plasma thrusters that is an order of magnitude beyond the current state-of-the-art, and will continue to investigate the concept of a dense plasma focus thruster using aneutronic fuels. Two pulse detonation test rigs will be under test to demonstrate the engineering feasibility of rocket engines based on this promising technology. Short track tests of a breadboard magnetic levitation device will be conducted to investigate its potential application to launch assist.

The Focused Program in Hybrid Propulsion will begin hot-fire testing of two different 250K-pound-thrust test motors in the test facility at MSFC. These test firings represent the final activity under this program.

Under the Focused Program in RLV Risk Mitigation, technology investments will begin in conformal, non-autoclave composite cryotanks, light-weight advanced metallic and ceramic thermal protection systems, and light-weight rocket engine materials/components.

Under the Focused Program in Low-Cost Upper Stages, NSTAR hardware will be installed on the DS-1 spacecraft starting in January 1998 in preparation for the July 1998 launch, and a second flight set of hardware will begin pre-flight qualification testing. A program to develop and flight-qualify Hall-effect electric propulsion systems will be initiated under the IHPRPT program. The initial target will be to develop a U. S. source for 10-20 kilowatt systems for application to orbit insertion of communication satellites. This represents a significant step toward development of high-power electric propulsion for future exploration missions. Shooting Star will complete integration for the solar thermal propulsion flight experiment, which is 'anticipated to occur in FY 1999.

In FY 1998. Engineering Capability Development will also continue to support aerothermodynamic test capabilities at LaRC and ARC. Future funding for these facilities, if required, will be budgeted within the Aeronautics Research arid Technology base.

In FY 1999, the Core Technology Propulsion Systems program will pursue the development of conceptual RBCC engine designs to support a potential flight demonstration. Advanced rocket propulsion technology activities will support planned government/industry IHPRPT demonstrator and component technology developments. Planned activities include ceramic matrix composites for turbomachinery components and nozzles, metal matrix composites for housings and internal components, smart valves, and analytical design tools and life prediction techniques.

The Core Technology Airframe Systems Program will expand investments in structures and materials, cryogenic tanks, thermal protection systems (TPS), avionics/operations, and system analysis, design and integration. Development and demonstration areas include advanced composites and refractory composite hot structures, technologies for joining both structure and cryotankage, ultra-high-temperature ceramics thermal protection materials, instrumentation for vehicle health monitoring, and highly reliable avionics systems. Subscale structures, tanks, TPS panel arrays, and avionics breadboard demonstrations will take place. Results will be used to validate and update analytical models of a range of space transportation concepts.

The Core Technology Space Transportation Research program will pursue proof-of-concept research in technology areas that may lead to significant reductions in the cost of access to space or may enable new space missions. In the area of revolutionary rockets, tests will be performed on several pulse detonation rocket engines that will have been built during the previous year. In the area of exotic fuels, research will be initiated jointly with NASA and the Air Force Phillips Lab at Edwards in high-energy-density fuels based on atomic recombination energy and on strained ring hydrocarbons. Additionally, advanced concepts for hydrogen storage and other advanced materials concepts will be performed to support long-term space missions. In the area of launch assist, tests will be performed on several magnetically levitated and propelled proof-of-concept models to quantify the potential benefits of providing a launch vehicle with an initial boost from a ground-powered device. Free-flight tests will also be conducted using a ground-based laser on a small test article. Experiments will be conducted on very advanced, high-power electric thrusters and advanced energy concepts, including experiments with antimatter catalyzed fusion, dense plasma focus pulsed fusion, and magnetic nozzles for a plasma rocket.

The Focused Program in RLV Risk Mitigation will expand efforts to pursue alternative or back-up technology approaches to those currently in the X-33 and X-34 programs, as well as new technology approaches that have been discovered since the fixed-funding X-33 and X-34 programs were begun. Small-scale non-autoclave composite cryogenic tanks and structures will be built and tested, and construction will begin on large-scale tanks and structural test articles. Advanced metallic and ceramic TPS panels will be built and tested in arc-jet tunnels and other ground facilities. Small-scale engine components using light-weight ceramic matrix composites will be built and tested. Breadboard IVHM/avionics systems will be constructed for testing

The Focused Program in Low-Cost Upper Stages will continue mission profile testing of the NSTAR system on the ground with the alternate flight propulsion system, and will also complete data analysis from the DS-1 flight system. Advanced Ion and Hall-effect thruster developments will continue with emphasis on increased cathode life and improved power processor designs. A 10-kilowatt breadboard system will be assembled and tested for potential application to next-generation satellites. Minor investments will begin in technologies for atmosphere-assisted entry for planetary missions and earth-orbit return.

In FY 1998, initial studies on the Liquid Flyback Booster (LFBB) and the applicability of the X-38 program to a Crew Transfer Vehicle (CTV) will be complete. These studies, in conjunction with ongoing RLV technology and business plan development, will form the inputs for industry-led trade studies in FY 1999 and FY 2000 on a future NASA space transportation architecture. The results of these studies will inform NASA and the Administration's end-of-the-decade decision on the pursuit of an operational launch system to reduce NASA's launch costs, as called for in the National Space Transportation Policy (NSTC-PD4). A terms of reference document concurred in by the Administration will provide the basis for conducting these industry-led studies.

Commercial Technology
Programs

SCIENCE. AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TRANSPORTATION TECHNOLOGY — **COMMERCIAL TECHNOLOGY/SBIR**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999	Page Number
		(Thousands of Dollars)		
Commercial Technology Programs	25.800	25.200	23.200	SAT 4.3-2
Technology Transfer Agents	7.800	20.000	7.200	SAT 4.3-5
Small Business Innovation Research Programs	125.000	101.500	100.000	SAT 4.3- 10
Total	158,600	146.700	130.400	
Johnson Space Center	18.818	16.702	16.155	
Kennedy Space Center	5.578	6.012	5.067	
Marshall Space Flight Center	33.517	29.760	30.921	
Stennis Space Center	3.912	3.463	3.658	
Ames Research Center	15.723	15.022	12.832	
Dryden Flight Research Center	3.743	3.317	3.312	
Langley Research Center	23.204	17.303	16.893	
Lewis Research Center	17.947	16.125	14.370	
Goddard Space Flight Center	28.491	24.977	22.527	
Jet Propulsion Laboratory	2.284	3.400	2.735	
Headquarters	5.383	10.619	1,930	
Total	158,600	146.700	130.400	

Two elements of the Agenda for Change are particularly important for the overall goal to be reached. The first element involves the establishment of metrics which allow program managers lo determine the success rate of the various strategies. Four categories of metrics now exist, including inventory, technology, partnership. and success story metrics. The other element is the creation and maintenance of a new information network for commercial technology transfer. This network is now fully operational and accessible to the public via the Internet, and includes all current, non-sensitive technology activities and opportunities. To succeed, the commercial technology mission must become a responsibility of every NASA employee, contractor and industry and academic partner. The Agenda for Change marks the beginning of NASA's new focus, management commitment, and employee empowerment to improve our contributions to America's economic security through the pursuit of our aeronautics and space missions. All NASA program offices and field centers are beginning to invest appropriately in technology commercialization efforts, and NASA has adopted a near-term target of investing 10-20 percent of the agency's R&D budget in commercial partnerships with industry by the end of FY 2000

MEASURES OF PERFORMANCE

Increase the percentage of NASA R&D Invested in Commercial Partnerships with a goal of achieving 15%. Plan: October 1997 Actual: January 1998	Showing steady improvement toward reaching 20% will provide assurance that we can meet the upper range of the National Performance Review goal for the agency. Original date was revised to allow Centers to submit data for a more complete status report on partnerships.
Expand training program for NASA R&D program managers. Plan: April 1998	Expanded training should help foster the agency's internal culture change necessary to increase technology transfer and partnerships with private industry.
Assess approximately 100% of NASA technology for commercial application. Plan: December 1998	Current inventory of technology will be reviewed, assessed and rated for commercial potential.
Increase percentage of NASA R&D Invested in Commercial Partnerships with a goal of achieving 15-20% Plan: December 1999	Showing steady improvement toward reaching 20% will provide assurance that we can meet the upper range of the National Performance Review goal for the agency

ACCOMPLISHMENTS AND PLANS

In FY 1997, the emphasis was on increasing commercial partnerships with industry and continuing refinement of the technology and partnership database, updating it to include new Agency contracting efforts and to describe new technologies that are to be made public on the electronic network. The Agency met the FY 1997 goal of increasing the percentage of the NASA nietrics to include inventory, technology, partnership and success story metrics. The Agency also improved a new information network for commercial technology transfer. The partnership goal was achieved, and there was an increase in R&D partnerships from 10 to 15 percent of the relevant NASA R&D program. In addition, the commercial technology program significantly improved the technology infomiation available to the public and the efficient management of the technology database.

NASA TechTracS is an electronic network database system used to help manage NASA's technology and is contained within Technology Transfer Agents in FY 1998. Beginning in FY 1999, TechTracS will be included within the Electronic Network element of the Commercial Technology Program.

In FY 1998 and FY 1999, the emphasis will be on increasing commercial partnerships with industry and continuing refinement of the technology and partnership database, updating it to include new agency contracting efforts and to describe new technologies that are to be made public on the electronic network. The agency's goal for these years will be to increase the percentage of the NASA R&D budget in commercial partnerships with industry to 15 percent in FY 1998 and 15-20 percent in FY 1999. In FY 1998 and FY 1999, NASA will also continue to utilize and improve the Internet as an electronic marketplace for NASA technology assets, facilitating technology transfer and commercialization opportunities between U. S. industry and NASA. In addition, a series of training opportunities focused on the commercial technology strategy and its implementation actions will be expanded within NASA's standard program management professional training program as this program continues to evolve.

BASIS OF FY 1999 FUNDING REQUIREMENT

TECHNOLOGY ANSFER AGENTS

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
National Technology Transfer Center	7,800	7,200	7,200
NASA TechTracS		600	
Special Interest Proiects	---	12.200	--
Total Technology Transfer Agents	7,800	20,000	7,200

PROGRAM GOALS

The goal of technology transfer agents, such as the National Technology Transfer Center (NTTC),the Midwest Regional Technology Transfer Center, and the Business Incubator Program is to facilitate the transfer and conimercial use of federally-sponsored research and technology (and associated capabilities) to the U. S. private sector. The increased use of this research and technology will enhance U. S. economic growth and industrial competitiveness.

STRATEGY FOR ACHIEVING GOALS

In conformance with Congressional direction, NASA has funded the NTTC at Wheeling Jesuit College in West Virginia since 1990 to serve as a national resource for the transfer and commercialization of federal research and technology. A key strategy is to align and integrate NTTC operations with the NASA Commercial Technology Programs in support of the NASA Commercial Technology Mission/Agenda for Change. The cooperative efforts with NASA provide a foundation upon which the NTTC may fulfill its national role through technology transfer programs funded by other federal agencies and the provision of cost-recovery products and services. Accordingly, NASA has facilitated the involvement of other federal agencies to leverage and extend NTTC capabilities funded by NASA and has enabled the NTTC to implement cost-recovery activities in support of the overall federal technology transfer mission.

In accordance with the NTTC's national role and the NASA Commercial Technology Mission/ Agenda for Change, the NTTC performs four core roles: (1) to serve as a national gateway for federal technology transfer and commercialization, assisting U. S. industry to locate and access federally-sponsored technology resources and sources of technical/business assistance; (2)to develop, integrate and utilize national databases to enable efficient access to federally-funded research and technology resources; (3) to develop and deliver professional-level training in technology transfer and commercialization for federal agencies and other public and private sector audiences: and (4)to promote U. S. industry awareness and utilization of NASA and other federally sponsored research and technology resources available for commercial purpose.

NASA TechTracS, previously funded by the NTTC, has been separately identified. Beginning in FY 1999, TechTracS will be included within the Electronic Network element of the Commercial Technology Program,

Consistent with Congressional direction in House Report 105-297, the FY 1998 Commercial Technology Program includes funds for Special Interest Projects. These projects include: eye tracking technology miniaturization for assistance to the physically disabled: a research and demonstration program to further accelerate application of personal cooling technology for multiple sclerosis patients; Software Optimization and Reuse Technology Program; enhancement of NTTC activity; a special Midwest RTTC business outreach project; and a NASA (technology) Business Incubator program. The Business Incubator program will establish an environment that helps entrepreneurs use NASA technology to develop new products and services. The focus will be to provide new technology and technical expertise from NASA in partnership with support from non-federal sources to provide the technical foundation for new businesses.

MEASURES OF PERFORMANCE

In partnership with NASA, implement six national conferences, including Tech 2007 Plan: September 1998	Furthers the Agenda for Change goal of marketing NASA's capabilities. Tech 2007 was completed during the first quarter FY 1998; follow-on technology symposiums will also be supported in FY 1998.
In partnership with NASA, target specific industries and companies who may benefit from NASA technology and develop marketing strategies to those industries and firms. Plan: September 1998	Supports the Agenda for Change goal of marketing NASA's capabilities. The results will be establishing R&D partnerships with industry leading to new products and services based on NASA technology.
In partnership with NASA, expand and deliver Commercial Technology training courses. Plan: September 1998	Supports the Agenda for Change goal of fostering an internal agency culture change through training and education. Course has now been developed, and is to be delivered on a recurring basis. *Also,* selected training courses will be provided at the Centers and via distance-learning methods.
In partnership with NASA, develop and deliver a professional training program for US industry. Plan: September 1998	The goal of this training will be to better enable companies to successfully commercialize NASA technology.

Increase the number of qualified inquiries from marketing activities to the public for referral to NASA Centers. Plan: September 1999	Process a minimum of 6,000 inquiries for NASA technologies in FY 1999
Increase the number of referrals for NASA technology Plan: September 1999	The NTTC will be able to assess and service the industry technical need inquiries for at least 600 qualified referrals for NASA technologies in FY 1999.
Increase access to Commercial Technology training Plan: September 1999	Conduct 25 training events and courses with NASA in FY 1999.
Increase the Assessment/Partnering between NASA and Industry Plan: September 1999	Complete 50 in-depth commercialization potential assessments of NASA technologies, and qualify and assist licensing/ partnering agreements for 10 NASA technologies in FY 1999.

ACCOMPLISHMENTS AND PLANS

In cooperation with NASA, the NTTC has implemented marketing and outreach activities (e.g. public service announcements, trade shows, direct mail, publications and Internet/ Web-sites) with NASA to generate U. S. industry awareness of, and interest in, utilizing and commercializing NASA technologies. The NTTC gateway has serviced the resulting inquirers, leading to qualified referrals to NASA technologies and industry access to and partnering with NASA field centers. The NTTC has also teamed with NASA to develop and deliver a set of training courses designed to improve the knowledge and application of skills and methods for technology transfer and commercialization across NASA. The NTTC began In FY 1997 to develop distance learning and Internet-based training activities currently underway. The NTTC is established within the NASA community as a fully recognized partner for technology transfer/ commercialization training. In addition, the NTTC developed new capabilities in FY 1997 to perform market and technology assessments and to facilitate the technology commercialization process. The NTTC plans to build upon these activities and capabilities in FY 1998 to perform their four key roles as well as to leverage and extend the NASA-funded capabilities to implement cost-recovery products/ services and to conduct activities funded by other federal agencies.

The NTTC is currently implementing its fourth year of operations under a five year cooperative agreement with NASA. The final year of this agreement will be implemented in FY 1999. Accordingly, NASA will be assessing the NTTC's performance and capabilities relative to the NASA Commercial Technology Mission during the remainder of the agreement to determine the requirements and appropriate funding instrument for a possible follow-on agreement in FY 2000.

In conforniance with FY 1996 Congressional direction, NASA awarded a four-year Cooperative Agreement to Montana State University (MSU) to establish and operate a rural technology transfer and commercialization center (known as the NASA/MSU TechLink Center) to assist companies and targeted industries in Montana, Idaho, N. Dakota, S. Dakota and Wyoming to utilize and commercialize technologies from NASA, federal laboratories and universities to improve competitiveness and expand business opportunities. The Center, utilizing the funds provided over a four year period, provides services to targeted industries (e.g., agriculture; mining, oil and gas, environmental services) directed towards creating technology partnerships with NASA and other federal/university technology sources, and fostering successful technology commercialization and business development within the upper plains region. The Center successfully completed its start-up year objectives in May 1997, capping off the year by brokering its first technology commercialization partnership between the NASA Stennis Space Center and a Montana remote sensing company. The Center, now fully operational, is expected in FY 1998 to facilitate at least six additional technology partnerships, continue client services for technology commercialization, expand activities throughout its operating region, and further strengthen relationships with the NASA field centers and other NASA Commercial Technology Program operations. The Center, subject to the continual improvement of operations, will continue these activities in FY 1999.

BASIS OF FY 1998 FUNDING REQUIREMENT

SMALL BUSINESS INNOVATION RESEARCH PROGRAMS

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Small Business Innovation Research..	125,000	101,500	100,000

PROGRAM GOALS

The goals of **NASA's** Small Business programs are to promote the widest possible award of **NASA** research contracts to the small business community as well as to facilitate commercialization of the results of this research by the small business community.

STRATEGY FOR ACHIEVING GOALS

Established by Congress, the Small Business Innovation Research (SBIR) program and the Small Business Technology Transfer (STTR) programs help **NASA** develop innovative technologies by providing competitive research contracts to U. S. owned small businesses. The program is structured in three phases:

Phase I is the opportunity to establish the feasibility, technical merit and desirability of a proposed innovation. Selected competitively, Phase I contracts last for six nionths and currently do not exceed $70,000.

Phase II is the major R&D effort in SBIR. The most promising Phase I projects are selected to receive contracts worth up to $600,000 and lasting up to two years. In general, about 50 percent of Phase I projects are approved for Phase II.

Phase III is the completion of the development of a product or process to make it marketable. The financial resources cannot come from SBIR funds. Private sector investment in various forms is the usual source of Phase III funding.

The FY 1997 **NASA** SBIR solicitation includes 28 major topic areas divided into 118 sub-topics. The description of each of these sub-topics is developed by various **NASA** installations to include current and foreseen Agency program needs and priorities. **NASA** typically receives 262 1 individual proposals; a 10% increase from the previous FY 1996 solicitation. In each solicitation, proposals are evaluated by the **NASA** field centers for scientific and technical merit, key staff qualifications, soundness of the work plan and anticipated commercial benefits. **NASA** Headquarters (HQ) program offices provide additional insight into commercial applications, program balance, and critical Agency requirements. Selections are made by **NASA** HQ based upon these reconimendations and other considerations. Typically about 400 Phase I awards are selected each year.

In addition to an extensive on-line database regarding the program, NASA also provides information for public access via a bulletin board service and Internet servers. Moreover, NASA has begun to use information technology for the process of developing the technical sub-topics in the solicitation, for the public release of the solicitation in electronic formats and for proposal evaluation. The end-to-end electronic solicitation process is serving as a prototype not only within NASA, but across the government.

Several other innovations have been introduced or strengthened this past year in the small business programs. A detailed, external evaluation of each proposal's ultimate commercial potential is now included in the selection process. In addition, a comprehensive, systematic review of past SBIR projects' post-Phase II, commercial and or mission applications has been initiated. The information from the review will be used to identify critical predictors of commercial viability and, therefore, to increase the effectiveness of the programs. Finally, a new approach is being continued and strengthened to focus several sub-topics into specific NASA mission applications. The intent is to more closely tie the SBIR activity to the primary mission needs of each NASA enterprise. The pathfinder for this program has been a collection of sub-topics in the general aviation program.

The NASA SBIR program has contributed to the U. S. economy by fostering the establishment and growth of over 1100 small, high-technology businesses. At least 225 private ventures have been initiated based on NASA SBIR programs. Twenty major participants have produced more than $150 million in new revenues.

MEASURES OF PERFORMANCE

The program supports measures of performance in multiple areas: The program must be operationally implemented in a manner that maximizes the potential for successful outcomes. Therefore a set of metrics for successful completion of each solicitation (Pre-solicitation, Solicitation, Selection/Award, and Post-Award activities) continued to be refined and used to assess the operational and management performance of the program.

The Agency is in the process of obtaining commercialization metrics (revenue, jobs creation) from previous SBIR/STTR awardees in order to better measure the SBIR Program contribution to the overall success in meeting the agency commercialization objectives.

Select and announce new SBIR Phase I awards resulting from the FY 1996 solicitation Plan: January 1997 Actual: January 1997	Initiates awards for new solicitation. All supporting activities completed successfully and as planned.
Complete development and issue the FY 1997 SBIR solicitation. Plan: April 1997 Actual: July 1997	Necessary to ensure the success of the FY 1997 research program. All supporting activities completed successfully ; programmatic delay inserted to strengthen program ability to meet revised cost carryover policy.

Select and announce new SBIR Phase I awards resulting from the FY 1997 solicitation. Plan: August 1997 Revised: February 1998	Initiates awards for new solicitations. All supporting activities completed successfully; FY 1998 plan that was submitted was in error, The period from solicitation to announcement is typically 170 Days, Program planned activities successfully rescheduled from November to reflect change in schedule described above.
Select and announce new SBIR Phase 11 awards resulting from the FY 1996 solicitation. Plan: December 1997 Actual: December 1997	Initiates follow-on awards resulting from prior Phase I results. All supporting activities completed successfully and as planned.
Complete development and issue the FY 1998 SBIR solicitation. Plan: April 1998	Necessary to ensure the success of the FY 1997 research program. Planning complete for initiation of initial solicitation development activities.
Select and announce new SBIR Phase II awards resulting from the FY 1997 solicitation. Plan: September 1998 Revised: December 1998	Initiates follow-on awards resulting from prior Phase I results. Revised date reflects impacts from schedule changes in FY 1997 Phase I activities.
Select and announce new SBIR Phase II awards resulting from the FY 1997 solicitation. Plan: September 1998 Revised: October 1998	Initiates follow-on awards resulting from prior Phase I results: provide initial assessment of commercial success of FY 1993 - 1997 awardees and overall program performance. Revised date in accordance with updated program schedule.
Select and announce new SBIR Phase I awards resulting from the FY 1998 solicitation. Plan: September 1998 Revised: November 1998	Initiates awards for new solicitation. Revised date in accordance with updated program schedule.

Perform commercial assessment FY 1996 outcome success arid complete development the FY 1999 SBIR solicitation Plan: June 1999	Ensure the success of the FY 1999 research program. Perform initial assessment of commercial success and overall performance of program
Select and announce new SBIR Phase II awards resulting from the FY 1998 solicitation Plan: November 1999	Initiates the follow-on awards resulting from prior Phase I results. Continue to assess commercial success of past awardees and overall perforniance of prograni.
Select and announce new SBIR Phase I awards resulting from the FY 1999 solicitation Plan: December 1999	Initiate awards for new solicitation. Continue to assess commercial success of past awardees and overall performance of program.

ACCOMPLISHMENTS AND PLANS

With the close of FY 1997, the implementation activities to realign the topic and subtopic focus of the SBIR/STTR programs toward Enterprise needs, and increase commercialization metrics collection from program awardees, to more adequately measure progress in commercializing technology, is essentially complete.

The performance metrics will include initial results of a survey conducted by a NASA SBIR firm that was recently initiated utilizing an OMB approved data collection instrument and methodology. The survey is designed to capture various measures of commercial activity associated with NASA funded SBIR technology. It is planned to have an initial program performance assessment available in mid FY 1998.

The original program period for the STTR pilot project has been extended; therefore, there will be activities initiated based on the assessment of the previous 3 years outcome and strategic plans developed for the reauthorized program through FY 2001. Program activities have already been completed for the STTR Program to reduce uncosted carryover for FY 1997 and FY 1998 . This required some adjustment in the award profile. However, future awards are anticipated to remain in approximately the same quantities as in FY 1996.

FY 1998 and 1999 will include new SBIR Phase I and Phase II awards, and continued emphasis on and evaluation of commercial successes and successful applications to NASA programs. By February 1998, 1996 Solicitation Phase II awards and 1996

Solicitation Phase 1 awards will be awarded and under contract or in contract negotiation. In FY 1998. announcements will be made for the 1997 Solicitation Phase II awards and in FY 1999 the 1998 Phase I awards will be announced.

Comm tion
Service

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT | **MISSION COMMUNICATIONS SERVICES**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
Ground Networks	245,600	224,700	228,900	SAT 5-4
Mission Control and Data Systems	147,100	145,000	145,400	SAT 5-10
Space Network Customer Services	25,900	31,100	27,300	SAT 5-19
Pending Reduction	--	-5,000	-21,600	
Total........	418,600	395,800	380,000	

Distribution of Program Amount by Installation

	FY 1997	FY 1998	FY 1999
Johnson Space Center	3,450	1,000	4,500
Marshall Space Flight Center	1,300	2,100	300
Dryden Space Flight Center........	13,800	14,500	13,800
Lewis Research Center	11,101	10,200	10,100
Goddard Space Flight Center........	199,940	202,600	193,800
Jet Propulsion Laboratory	186,456	168,000	175,000
Headquarters........	2,553	2,400	4,100
Pending Reduction	--	-5.000	-21,600
Total,,........	418,600	395,800	380,000

PROGRAM GOALS

The Space Coniniunications goal is to enable the conduct of the NASA strategic enterprises by providing telecommunications systems and services. Reliable electronic communications are essential to the success of every NASA flight mission, from planetary spacecraft to the Space Transportation System (STS) to aeronautical flight tests.

The National Space Policy stipulates that NASA will "seek to privatize or commercialize its space communications operations no later than 2005". The Space Operations Management Office (SOMO), located at the Johnson Space Center, manages the telecommunication, data processing, mission operation, and mission planning services needed to ensure the goals of NASA's exploration, science, and research and development programs are met in an integrated and cost-effective manner. In line with the National Space Policy, the SOMO is committed to seeking and encouraging commercialization of NASA operations services and to participate with NASA's strategic enterprises in collaborative interagency, international, and commercial initiatives. As NASA's agent for operational communications and associated information handling services, the SOMO seeks opportunities for using technology in pursuit of more cost-effective solutions, highly optimized designs of mission systems, and advancement of NASA's and the nation's best technological and commercial interests.

The Mission Communications Services, one part of NASA's Space Communications program, are composed of Ground Networks, Mission Control and Data Systems, and Space Network Customer Service. These programs establish, operate, and maintain NASA ground networks, mission control, and data processing systems and facilities to provide communications service to a wide variety of flight programs. These include deep space, Earth-orbital, research aircraft, and sub-orbital missions. Mission support services such as orbit and attitude determination, spacecraft navigation and maneuver support, mission planning and analysis and several other mission services are provided. New communications techniques, standards, and technologies for the delivery of communication services to flight operations teams and scientific users are developed and applied. Radio spectrum management and data standards coordination for NASA are conducted under this program.

STRATEGY FOR ACHIEVING GOALS

The Space Communications program provides command, tracking and telemetry data services between the ground facilities and flight mission vehicles and all the interconnecting telecommunications services to link tracking and data acquisition network facilities. mission control facilities, data capture and processing facilities, industry and university research and laboratory facilities, and the investigating scientists. The program provides scheduling, network management and engineering, pre-flight test and verification, flight system maneuver planning and analysis. The program provides integrated solutions to operational communications and infomiation management needs common to all NASA strategic enterprises.

The range of telecommunications systems and services are provided to conduct mission operations, enable tracking, telemetry, and command of spacecraft and sub-orbital aeronautical and balloon research flights. Additionally, systems and services are provided to facilitate data capture, data processing, and data delivery for scientific analysis. The program also provides the high speed computer networking, voice and video conferencing, fax, and other electronic services necessary to administer NASA programs.

These communications functions are provided through the use of space and ground-based antennas and network systems, mission control facilities, computational facilities, command management systems, data capture and telemetry processing systems, and a host of leased interconnecting systems ranging from phone lines and satellite links to optical fibers.

The program provides the necessary research and development to adapt emerging technologies to NASA communications and operational requirements. New coding and modulation techniques, antenna and transponder development, and automation applications are explored and, based on merit, demonstrated for application to future communications needs. NASA's flight programs are supported through the study and coordination of data standards and communication frequencies to be used in the future. These are all parts of the strategic approach to providing the vital communications systems and services common to all NASA programs and to achieve compatibility with future commercial satellite systems and services.

Many science and exploration goals are achieved through inter-agency or international cooperation. NASA's Space Communications assets are provided through collaborative agreements to other US Government agencies, commercial space enterprises, academia and international cooperative programs. Consistent with the National Space Policy, NASA will procure commercially available goods and services to the fullest extent feasible, and will not conduct activities with commercial application that preclude or deter commercial space activities.

The Mission Communications Services program, one part of NASA's Space Communications program, provides systems and services to a large number of NASA missions, including planetary and interplanetary missions; human space flight missions; near-Earth and Earth-orbiting missions: sub-orbital and aeronautical test flights.

Efforts are ongoing to consolidate and streamline major support contract services in order to optimize space operations Transition to a Consolidated Space Operations Contract (CSOC) is planned in FY 1998. The CSOC acquisition process is being implemented in two phases. Two 8-month fixed-price study contracts were awarded to Boeing North American and Lockheed Martin, Incorporated on May 16, 1997 to develop an Integrated Operations Architecture (IOA). The IOA and a proposal to implement the architecture are due to NASA in January 1998. NASA intends to award a single cost-plus-award-fee contract to implement the IOA and to provide space operations services during a five-year basic contract, with a five-year option. The 90-day phase-in period is planned to start on July 1, 1998. This full and open competition is expected to produce efficiencies and economies over the life of the contract which benefits all NASA programs. Specially, the integrated architecture is expected to maximize space operations resources by reducing systems overlap and duplication. Efforts are ongoing to develop a Space Operations pricing policy, including the pricing of contractor provided services and how each Enterprise will pay for services. In addition, the Agency's pricing policy will be incorporated under the CSOC and full-cost accounting. Programmatic content in FY 1999 will be reduced by $21.6Million. The impacts of this reduction has not yet been identified, however, it is anticipated that the overall cost of space operations (Space Communications Services and Mission Communication Services) will be reduced with the advent of the Consolidated Space Operations Contract (CSOC) beginning in FY 1999. In addition, efforts will be undertaken to consider opportunities to accelerate the National Space Policy directive that NASA seek to privatize or commercialize its space communications operations no later than 2005.

BASIS OF FY 1999 FUNDING REQUIREMENT

GROUND NETWORKS

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Deep Space Network - Systems	98,648	79,100	83,900
Deep Space Network - Operations	82,952	82,800	85,200
Spaceflight Tracking and Data Network - Systems	2.400	3,000	2,300
Spaceflight Tracking and Data Network - Operations	19,300	17,100	15,200
Aeronautics, Balloons, and Sounding Rockets - Systems....	19,200	13,100	12,300
Aeronautics, Balloons, and Sounding Rockets - Operations	23,100	29.600	30,000
Total.,..	245,600	224.700	228.900

PROGRAM GOALS

The Ground Networks program goal is to provide high quality, reliable, cost-effective ground-based tracking, command and data acquisition systems and services for NASA science and aeronautics programs. Launch, emergency communications, and landing support for the Space Shuttle is also provided by the Ground Networks facilities. The program provides for the implementation, maintenance and operation of the tracking and communications facilities necessary to fulfill program goals for the NASA flight projects.

The Ground Network program also supports NASA programs in collaborative interagency, international, and commercial enterprises and independently provides support to other national, international and commercial enterprises on a reimbursable basis.

STRATEGY FOR ACHIEVING GOALS

The Ground Networks program is comprised of the following elements: the Deep Space Network (DSN), managed by the Jet Propulsion Laboratory (JPL); the Spaceflight Tracking and Data Network (STDN), managed by the Goddard Space Flight Center (GSFC); the Aeronautics, Balloon and Sounding Rocket (AB&SR) tracking and data acquisition facilities managed by GSFC/Wallops Flight Facility (WFF); and the Western Aeronautical Test Range (WATR), managed by the Dryden Flight Research Center (DFRC). The AlliedSignal Technical Services Corporation and the Computer Sciences Corporation are currently the primary support service contractors responsible for ongoing engineering, maintenance and operations of the Ground Networks.

The number of missions serviced by the DSN facilities and the needs of the individual missions will increase dramatically over the next several years. In anticipation of the increases, new antenna systems have been developed and obsolete systems are being phased out or converted for alternate uses. The DSN has been reconfigured with three new 34-meter antenna systems located at Goldstone, California; Canberra, Australia; and Madrid, Spain. These 34-meter antennas will enable the expanded coverage requirements and provide simultaneous coverage of two deep space missions which are in critical phases. In Goldstone, two new 34-meter antennas became operational in FY 1995 and FY 1996. In Canberra, one became operational in FY 1997. In Madrid, one became operational in FY 1998. In addition, an experimental 34-meter antenna. Located at Goldstoneis currently supporting the European Space Agency (ESA)-NASA collaborative Infrared Space Observatory and Solar Observatory for Heliospheric Observations spacecraft. The DSN installed a new 11-meter antenna system at each DSN complex to provide data acquisition capability for the Institute of Space and Astronautical Science (ISAS) Japanese VLBI Space Operation Program (VSOP) spacecraft, which was launched in February 1997,

New Ground Networks capabilities include two 11-meter antenna systems installed near Fairbanks, Alaska and at Svalbard, Norway to provide command and data acquisition support for the expanded number of Earth-observing missions which will includes EOS AM-1 and Landsat-7 in FY 1998. Also, the Leo Earth Orbit Terminal (LEO-T)contract has been expanded to provide three autonomous 5-meter ground stations for space science mission support. The first of these systems will be installed in Puerto Rico and will be operationally ready to support the Far Ultraviolet Spectroscopy Explorer (FUSE)mission in FY 1998.

The strategy for achieving the above goals has several major elements. The DSN is the premier facility for tracking deep space probes, occasionally supplemented by the facilities of other agencies or nations. NASA is actively working with industry to foster the enhancement of existing "commercial-off-the-shelf" systems to expand their applicability so that inexpensive and reliable communications services can be readily obtained for the new small-class missions. Future missions will be supported by small, inexpensive, commercially available tracking systems, enabled by such tools as the Very Large Scale Integration (VLSI) High-Rate Frame Synchronization and Data Extraction chips which have been transferred to industry. The Ground Networks program, in conjunction with other NASA elements, is demonstrating and implementing Global Positioning System (GPS) flight units on NASA sponsored missions. This demonstration will seek to minimize future tracking and navigation activities. The planned Student Nitric Oxide Explorer (SNOE)mission will demonstrate these new capabilities using commercial flight units as the primary source of this function. The Western Aeronautical Test Range is striving for even more efficiency as it provides NASA's capability for tracking, data acquisition, and mission control for a wide variety of flight research vehicles. The WATR provides both on-orbit and landing support to the Space Shuttle and communications with the Mir Space Station. Intense planning is underway to support the Reusable Launch Vehicle (X-33) and other wide range of vehicles with WATR resources.

The DSN has several on-going re-engineering efforts. These new processes will allow the DSN to increase the tracking hours delivered while reducing costs. The processes to be implemented include: moving toward giving the operators end-to-end control of the entire data acquisition process; redesigning systems that provide support data to allow automation and quicken response time; and developing a process to better define DSN services and allow customers to choose only the services necessary to support the mission.

A major restructuring of the DSN architecture will begin which will greatly reduce the cost of operations, sustaining, and maintenance of the network. Restructuring will include separating the electronics of the 26-meter antennas from those of the

34-meter and 70-meter antennas used to support Deep Space Missions, and upgrading the older electronics in the 34-meter and 70-meter antennas with simpler, commercial components that are easier to maintain and operate. These efforts will last through FY 2002.

Efforts to reduce the cost of operations for low-Earth orbit spacecraft will continue with development of new technology and operational processes. The goal of these efforts is to provide turn-key mini-systems that can be operated directly by the flight projects. This concept will be validated by the SNOE Project. Re-engineering efforts will continue on the STDN facilities to reduce operation and maintenance costs. NASA will close the Bermuda station in FY 1998, following completion of two planned Space Shuttle modifications. One will permit earlier communications through the Tracking and Data Relay Satellite (TDRS) during the launch phase of the mission and the second will allow onboard use of the GPS to replace the use of ground radar for Space Shuttle navigation.

NASA will pursue, within the CSOC, commercial ground tracking services for low-Earth orbit missions that require this support. Transition activities to the commercial operator are expected to begin in FY 1999. Upon successful completion of transition activities, the 26-meter subnet will be operated at a reduced level until FY 2001 in order to meet prior commitments. The DSN will return to servicing only deep space missions, highly elliptical Earth orbiting missions, launch and early orbit phase, ground-based radio astronomy, and planetary radar astronomy activities.

MEASURES OF PERFORMANCE

	FY 1997		FY 1998		FY 1999
	plan	Actual	plan	Current	
Deep Space Network					
Number of NASA missions	45	45	45	52	51
Number of hours of service	90,000	90,000	92,000	92,000	94,000
Spaceflight Tracking and Data Network					
Number of Space Shuttle launches	7	8	7	6	8
Number of ELV launches	18	25	6	25	25
Wallops Flight Facility					
Number of NASA Earth-Orbiting missions	33	30	33	33	32
Number of Sounding Rocket deployments	25	32	25	31	27
Number of Balloon deployments	26	12	26	26	26
Number of hours of service (Wallops Orbital Tracking)	23,000	14,695	26,000	26,000	24,000
Western Aeronautical Test Range					
Number of NASA missions	1,100	750	1,100	1,100	750
Number of NASA research flights	400	660	400	750	900

DSN support of NASA missions and hours of service are dictated by actual launch dates and associated mission support requirements. In the WFF area, the change in the number of NASA earth-orbiting missions in FY 1998 reflects a net increase in the number of missions to be supported based on documented requirements; new missions include: Earth Observing System (EOS) AM-1 and LANDSAT-7. The other increases shown are based on the current mission model reflecting planned support. Planning and development work on major priority missions such as the X-33, Hyper-X and Linear Aerospike SR-71 Experiment consumed much of the WATR resources. The increase in research flights was due to pre-flight and ground tests for UAV's and the Linear Aerospike SR-71 Experiment LASRE.

CONSOLIDATED SPACE OPERATIONS CONTRACT (CSOC)

Phase 1 Contract Award	May 1997
Phase 2 Proposal Due	Jan 1998
Phase 2 Contract Award	Jun 1998
Phase 2 Phase-In	3rd QTR 1998
Phase 2 CSOC In Force	OCT 1998

The CSOC measures of performance apply to Ground Networks, Mission Control & Data Systems and Space Network Customer Services.

ACCOMPLISHMENTS AND PLANS

Spaceflight Tracking and Data Network (STDN)

The Space Shuttle launches were successfully supported through dedicated facilities of the STDN. The two major requirements for the STDN are to be available during the launch countdown sequence so as not to cause a launch hold condition, and to provide at least 99% of the Space Shuttle data during the launch phase. The continuation of this support, further enabled by the implementation of the re-engineered STDN system elements, is expected throughout FY 1998 and FY 1999.

The STDN will consist of the MILA station and the Ponce de Leon inlet annex in support of Shuttle Launch and landing activities. The aging 9-meter hydraulic antennas at MILA are to be replaced with electric drive systems. capable of functioning without an operator. Efforts in support of this initiative will begin in FY 1999. Technology developed in support of receiver, exciter, and ranging subsystems will be introduced in a phased manner to replace aging subsystems at MILA and Ponce de Leon.

Wallops Flight Facility (WFF)

WFF completed the installation of the 1l-meter telemetry antenna systems at the Poker Flat Research Range near Fairbanks, Alaska and at Svalbard, Norway in preparation for support of the EOS AM-1 and Landsat-7 missions. Ground station and network integration and certification testing will be completed in the first half of FY 1998. The contract for the LEO-T systems was modified to include the delivery of three systems to be installed at Puerto Rico, Wallops Island, and Poker Flat. These systems will all be installed in FY 1998 and will provide a cost-effective command and data acquisition capability for low earth orbit missions.

Low Earth orbit, expendable launch vehicle. sounding rocket, and atmospheric balloon mission support will be provided by a mix of permanent and transportable command, control, data acquisition, and tracking facilities. Successful support of two Pegasus launch operations was completed: one of them, MINISAT, from a mobile range deployment to the Canary Islands. The Redstone antennas recently installed at Poker Flat and at the White Sands Missile Range have successfully supported the NASA Sounding Rocket Program. Mobile support requirements for FY 1998 include missions in Norway and Puerto Rico. Planning continues for the mobile range support of the X-33 mission in California in FY 1999.

The WFF modernization upgrade of the FPQ-6 radar will be completed in FY 1998. Work will be initiated on the replacement of the Wallops Range Data Acquisition and Computational System; this system is a range safety tool and is obsolete and expensive to maintain. The acquisition of commercially available and maintainable, PC-based, telemetry front-end processors will be completed; these systems will be common to all Wallops ground stations and will replace obsolete, custom built, expensive-lo-maintain systems currently in use. Work on the 11-meter antenna system upgrades required to support the Advanced Earth Orbiting Satellite (ADEOS) II mission will be initiated. Work will also begin on the development of a new niobile telemetry system to meet the increasing demands for off-range launch support of sounding rockets, recoverable launch vehicles, and expendable launch vehicles,

The development of the new niobile telemetry system is planned for completion in FY 1999. The 11-m antenna system upgrades for ADEOS II will be completed. Work will be initiated for the upgrade of the host computer in two of Wallops radars; the systems being replaced are aging mini-computers which are difficult and expensive to maintain; the upgrades include the use of commercially available VME-based computer components.

Deer, Space Network (DSN)

The DSN supported two launches of the Mars Exploration Program. The Pathfinder Mission landed in July 1997. and Mars Global Surveyor (MGS) began orbital operations in September 1997. The Galileo Mission continues in its extended Europa mission, using the DSN array mode. The Very Long Baseline Inteferometry Space Observatory Program (VSOP) spacecraft was launched in February 1997 and began a very complex operational scenario involving the 11-meter antennas for VSOP telemetry and the DSN 70-meter antennas for co-observing of the radio sources.

The 11-meter antennas are performing below expectations. DSN management has formed a tiger team to address hardware and software-deficiencies and has committed the resources needed to operate the antennas in a manual mode to achieve the required science return.

Both Cassini, bound for Saturn, and Lunar Prospector, a Discovery mission, were launched in FY 1998 and are being supported by the DSN in FY 1998. MGS will continue its orbital aerobraking and begin mapping the planet Mars. In July of 1998, the first of the Deep Space New Millennium missions will launch. About a month later, the Japanese Space Agency, ISAS, will launch Planet B, a Mars mission which will be supported by the DSN on a cooperative basis. The DSN will support the December 1998 launch of the Mars '98 Orbiter, the January 1999 launch of the Mars '98 Lander, and the February 1999 launch of Stardust, a solar wind sample return mission.

The capability to receive data from two spacecraft at a single beam has been implemented. This is required because of the number of missions that will be orbiting on the surface of Mars. This implementation will allow the DSN to better use the limited number of antennas that are available. As planned, the aging DSN 34-meter standard antennas at Australia and Spain will be retired and their role assumed by the newly constructed 34-meter Beam Waveguide antennas. Decommissioning is planned for the first quarter of FY 1999. The age of the antennas and cost of year 2000 software upgrades makes continuation of operations impractical.

The DSN will begin implementing architectural changes in 1998. The changes will involve the upgrade and automation of the 26-meler antennas, separating their electronics from those of the 34-meter and 70-meter antennas, and the replacement of significant parts of electronics in the 34-meter and 70-meter antennas with simpler commercial components. This, combined with on-going network control modifications, which will complete in 1999, will lead to dramatically reduced costs of network sustaining, maintenance and operations. Automated equipment **will** enable a single "connection operator" at a Complex to control the acquisition of data from a spacecraft and deliver it to a project.

Western Aeronautics Test Range (WATR) at Dryden Flight Research Center

In order to safely support multiple long duration Unpiloted Aerial Vehicle (UAV) missions, the Flight Termination System (FTS), will be upgraded with a system that can be operated simultaneously from any of the three control rooms. This system will be in place later in FY 1998 in time to support the X-33, X-38, TIER III -, multiple ERAST projects and, in addition, the Air Force's TIER 2+ project.

Upgrades to the telemetry tracking stations and radar systems will be complete within the year. Improvements in performance will provide a safely margin for support of the many UAVs at Dryden as well as allowing for the transition of Space Shuttle on-orbit telemetry tracking support from the Goldstone Tracking Station to the WATR. Also, the upgraded radars will provide some of the on-orbit radar tracking support provided by the Bermuda Tracking Station due to be closed in FY 1999. Cyclic replacement of older equipment such as telemetry and video receivers will begin.

Upgrades underway in the Video Control Center (VCC) will allow for the distribution and recording of multiple video feeds from the X-33 launch pad. A more powerful camera lens will make it possible to track the X-33 during launch arid also high altitude UAVs. Additional improvements have been made in the long range communication capability which has improved the air-lo-ground link between research aircraft and the ground station. These same systems are also used to support the Space Shuttle.

The capability to process and display Global Positioning System (GPS) parameters was incorporated into the Mission Control Center (MCC) and used to support the F-18 Sequented Ranging Assembly (SRA). Other projects such as the UAVs have also used this new capability. The Global Real-time Interactive Map (GRIM) was upgraded to handle the added requirements of such projects as X-38, LASRE, X-36, and ERAST. The Test Evaluation Command Control System (TECCS) was installed in the MCC to provide a back-up to the GRIM. Current and future projects require even more performance from the MCC display work stations. These systems and others will continually be upgraded to meet new requirements.

The Telemetry and Radar Acquisition Processing System(s) (TRAPS) were upgraded to support four real-time Pulse Code Modulation (PCM) telemetry streams. In addition. the capability to process up to 32 streams of wide band Frequency Modulated (FM) and constant bandwidth data was incorporated into the TRAPS system. This was used successfully by the F-16 Supersonic Laminar Flow Control project and will be used by other projects in the future. Also, the capability to run the F-15 ACTIVE engine model software in real-time was demonstrated with success. Planned upgrades to the telemetry front end systeni are required to support such projects as X-33 and ERAST but will ultimately benefit all projects.

Upgrades to the post flight processing system will reduce the number of times the data is handled and make it available to more users in near real-time. This will reduce data processing time and improve the productivity of the research engineers.

The relocation of the mobile systems from the Ames Research Center (ARC) to DFRC was accomplished as planned. Mobile systems will continue to be upgraded to provide a quick response rapid deployment capability within the WATR. The increase in unpiloted vehicles has placed a high demand on this type of capability. A new system is being built to replace one of the old Mobile Operations Facilities (MOFs) and will be used to support the X-33 project. The Laser Tracker will be maintained long enough to support current commitments such as the T-38 Jet Inlet Redesign and will then be removed from service.

The relocation of aircraft from the ARC to the DFRC has provided more opportunities to send real-time data to remote locations. The presentation of research data in real-time to researchers remote from DFRC is a key element to the future success of the WATR and the research missions it supports. The "Virtual Flight Research Center" and "Virtual Control Room" concepts will evolve based on work already done within the mission control community and the application of new network technology.

BASIS OF FY 1999 FUNDING REQUIREMENT

MISSION CONTROL AND DATA SYSTEMS

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Mission Control - Systems	10,000	13,400	12,400
Mission Control - Operations	43,700	46,000	42,400
Data Processing - Systenis	41,300	41,700	48,200
Data Processing - Operations	52,100	43,900	42,400
Total	147,100	145,000	145,400

PROGRAM GOALS

The Mission Control and Data Systems program goal is to provide high-quality, reliable, cost-effective mission control and data processing systems and services for GSFC spaceflight missions; data processing for NASA's Spacelab program; and flight dynamics services for NASA flight projects. The program provides for data systems, telecommunications systems technology demonstrations, and coordination of data standards and communications frequency allocations for NASA flight systems. The Mission Control and Data Systems program provides for the implementation, maintenance, and operation of the mission control and data processing facilities necessary to ensure the health and safety and the sustained level of high quality performance of NASA flight systems. The program provides and demonstrates key technologies and innovative approaches to satisfy Strategic Enterprises' mission needs, to promote sustained U.S. economic and technological leadership in commercial communications, and to maximize NASA's ability to acquire commercial services that meet its communications and operations needs.

STRATEGY FOR ACHIEVING GOALS

The Mission Control and Data Systems program, primarily managed by the GSFC, is comprised of a diverse set of facilities, systems and services necessary to support NASA flight projects. The AlliedSignal Technical Services and Computer Sciences Corporation are the primary support service contractors responsible for ongoing engineering support. development, operations and maintenance, under the Consolidated Network and Mission Operations Support (CNMOS) performance based contract, established as a voluntary partnership in 1996.

The mission control function consists of planning scientific observations and preparing command sequences for transmission to spacecraft to control all spacecraft activities. Mission Operation Centers (MOC's) interface with flight dynamics, communications network, and science operations facilities in preparation of command sequences, perform the real-time uplink of command sequences to the spacecraft systems, and monitor the spacecraft and instrument telemetry for health, safety, and system performance. Real-time management of information from spacecraft systems is crucial for rapid determination of the condition of the spacecraft and scientific instruments and to prepare commands in response to emergencies and other unplanned events, such as targets of opportunity.

Mission control facilities operated and sustained under this program are Mission Operation Centers (MOC) for the Hubble Space Telescope (HST) program; the International Solar Terrestrial Physics (ISTP) Wind, Polar, and Solar Observatory for Heliospheric Observation (SOHO); X-ray Timing Explorer (XTE), TOMS-Earth Probe (EP) , Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX) and Fast Auroral Snapshot (FAST) missions, and the Multi-satellite Operations Control Center (MSOCC) which supports the Compton Gamma Ray Observatory (CGRO), Upper Atniosphere Research Satellite (UARS), Extreme Ultraviolet Explorer (EUVE), Earth Radiation Budget Satellite (ERBS), and International Monitoring Platform (IMP) missions. The Advanced Composition Explorer (ACE and Tropical Rainfall Measurement Mission (TRMM) are two recently launched missions also operated out of GSFC MOC's. Data processing support is provided for the ISTP/Geomagnetic Tail (Geotail) and Extreme Ultraviolet Explorer (EUVE) missions.

GSFC rehosted the EUVE MOC to the Transportable Payload Operations Control Center (TPOCC) architecture and collaborated to outsource EUVE mission operations to the University of California at Berkeley (UCB) in March 1997. EUVE level zero science processing operations are to transition to UCB in early FY 1998. SAMPEX operations were conducted in parallel at Bowie State University (BSU); BSU will assume complete operations responsibility in FY 1998.

The CGRO system is phasing into the TPOCC architecture of distributed workstations, first used for the SAMPEX mission. A pre-release CGRO TPOCC configuration supported engineering analysis in the successful FY 1997 CGRO orbit reboost operations, with TPOCC transition completion expected in mid-FY 1998. NASA's SAMPEX, FAST, and Submillimeter Wave Astronomy Satellite (SWAS) missions will be operated from a common control facility for Small Explorer missions. The SWAS Mission Operations Center has been completed. Tropical Rainfall Measuring Mission (TRMM) and Advanced Composition Explorer (ACE) MOC's have been completed. Transport Region and Coronal Explorer (TRACE), and Wide Field Infrared Explorer (WIRE) control centers are in development. These workstation systems will allow for increased mission control capability at reduced cost.

The first launch of a Medium-class Explorer (MIDEX) is currently scheduled for January 2000. Approximately one spacecraft per year will be launched, with potentially every other MIDEX mission operated from GSFC, dependent on successful Principal Investigator teaming arrangements. To minimize operations costs, plans for the MIDEX niissions include consolidating the spacecraft operations, flight dynamics and science data processing all into a single multi-mission control center. Many of the functions will be automated using a commercial expert system product. The control center system will be used for spacecraft integration and test, thereby eliminating the need and cost of unique spacecraft manufacturers integration and test systems.

Other mission control systems include the Space Shuttle Payload Operations Control Center (POCC) Interface Facility (SPIF) and the Command Management System. The Space Shuttle POCC Interface Facility is being upgraded with a low cost PC-based front end data system, now operating in shadow mode. The SPIF provides a single interface to Mission Control Center for use of spacecraft mission control facilities to access spacecraft deployed by the Space Shuttle. The Command Management System generates command sequences to be used by mission control centers. A User Planning System, currently being upgraded to a workstation based environment compatible with the Network Control Center (NCC) configuration, is provided for scheduling communications with spacecraft supported by the Tracking and Data Relay Satellite System (TDRSS); the Flight-to-Ground Interface Engineering

Center provides flight software pre-flight and in-flight simulation and development support for GSFC flight systems: and, an Operations Support Center maintains status records of in-flight NASA systems.

The data processing function captures spacecraft data received on the ground, verifies the quantity and quality of the data and prepares data sets ready for scientific analysis. The data processing facilities perform the first order of processing of spacecraft data prior to its distribution to science operations centers and to individual instrument managers and research teams.

Data processing facilities include the Packet Data Processing (PACOR) facility, the Data Distribution Facility, and the Telemetry Processing Facility. The PACOR facility utilizes the international Consultative Committee for Space Data Systems data protocol to facilitate a standardized method of supporting multiple spacecraft, PACOR provides a cost-effective means of processing flight data from the following spacecraft missions: SAMPEX, EUVE, CGRO, SOHO, SWAS, XTE, TRMM, and HST. With the transfer of EUVE to UCB in FY 1998 and the relocation of CGRO processing to the workstation based PACOR II, FY 1998 will see the closure of the older and more expensive PACOR I system.

The Data Distribution Facility (DDF) performs electronic and physical niedia distribution of NASA space flight data to the science community. The (DDF) has been a pioneer in the use of Compact Disk-Read Only Memory technology for the distribution of spacecraft data to a large number of NASA customers.

Specialized data processing services are provided by the Telemetry Processing Facility for the ISTP missions (Wind, Polar, and Geotail), and the Spacelab Data Processing Facility, located at the MSFC, processes data from Space Shuttle payloads. Specialized telemetry processing systems for NASA's Space Network are also provided under this program.

The Mission Control and Data Systems program provides for the operation, sustainment, and iniprovement of NASA's Flight Dynamics Facility (FDF). Funding for the FDF is used to: provide orbit and attitude determination for operating NASA space flight systems, including the Tracking and Data Relay Satellite (TDRS) and the Space Shuttle; develop high-level operations concepts for future space flight systems; modify existing FDF systems to accommodate future missions; develop mission-unique attitude software and simulator systenis for specific flight systems; generate star catalogues for general use; and conduct special studies of future orbit and attitude flight and ground system applications. It is critical to continuously know the location of spacecraft so as to communicate with the system and to know the orientation of the spacecraft to assess spacecraft health and safety and to perform accurate scientific observations. The type and level of support required by spacecraft systems is dependent on the design of its on-board attitude and control systems, including its maneuver capabilities, and the level of position and pointing accuracy required of the spacecraft. Autoniated orbit determination systems for TDRS and other spacecraft systems are also under development.

Besides the operation of currently deployed spacecraft and the modification and development of mission control and data processing systems to accommodate new flight systems, the program also supports the study of future flight missions and ground system approaches, Mission control and first-order data processing systems are less costly systems. Yet, proper economy of mission planning requires solutions that integrate ground and flight system development considerations. Special emphasis is given by the Mission Control and Data Systems program to seeking integrated solutions to spacecraft and ground systems designs that emphasize spacecrafl autonomy: higher data transmission and processing rates; ease and low cost of operation; reuse of software:

and selected use of advanced hardware and software design techniques to increase the return of space flight system investments at equal or lower cost than is required to support today's mission systems.

The Mission Control and Data Systems program supports advanced technology development at GSFC, JPL and LeRC. The GSFC team, including contractors and universities, provides advanced technology in several areas, such as tracking and data acquisition future systems; communications and telemetry transport; and advanced space systems for users. Anticipating a future mission set characterized by large numbers of rapid, low-cost mission, the JPL team invests in technologies which can increase the overall capacity-to-cost ratio for the Deep Space Network. Efforts are focused on core technologies unique to, and critical for, deep space telecommunications, tracking and navigation, and radio science. Current technology areas include antenna systems, low noise systems, frequency and timing, radio metric tracking, navigation, network automation, atmospheric propagation and optical communications. The Lewis Research Center team identifies, develops, and demonstrates advanced radio frequency and digital communications technologies and services for use in NASA missions and commercial systems.

The Mission Communication Services advanced technology development has three forms: near term (1-3 years) demonstration and application of data management and teleconimunications technology and procedures: mid-range (3-5 years) development of ground and space flight communications systems; and long-term, pre-competitive technology development and denionstration. Consideration of innovative applications of commercial "off-the-shelf' technology is emphasized. Such applications often open new market opportunities to suppliers of these technologies resulting from their NASA experience.

A critical element of the Mission Control and Data Systems program is the securing of adequate frequency spectrum resources which are required in the performance of all flight missions, piloted and unpiloted, including spectrum for all active emitters as well as passive sensors. LeRC manages these resources for the Agency and coordinates frequency spectrum requirements with other federal agencies, industry and regulatory bodies to obtain all requisite authorization to operate teleconimunications systems associated with NASA programs. Consistent with its charter pursuant to both the Space Act of 1958 and the Communications Satellite Act of 1962, NASA is the primary advocate, both domestically and internationally, for obtaining the unique frequency spectrum allocations required by the commercial sector to exploit satellite technology for future generation telecommunications systems. In compliance with the 1992 Telecommunications Authorization Act, NASA actively participates in the Interdepartment Radio Advisory Committee to establish National and International management policies.

MEASURES OF PERFORMANCE

	FY 1997 Plan	FY 1997 Actual	FY 1998 Plan	FY 1998 Current	FY 1999 plan
Number of NASA spacecraft supported by GSFC mission control facilities	14	15	17	19	16
Number of mission control hours of service	50,000	47,000	55,000	56,000	40,000
Number of billions of bits of data processed	27,000	24,000	38,000	31,400	60,900
Number of NASA missions provided flight dynamics services	32	35	38	41	30

The actual FY 1997 column reflects ACE operations. The FY 1998 current plan reflects the TRMM, TRACE, Landsat-7, and EOS AM-1 launches. The number of missions provided flight dynamics services reflects the current mission model and includes pre-Phase A and Phase A support for missions such as Earth Orbiter (EO)-1, Venus 2000, and Next Generation Space Telescope. The FY 1999 mission projection reflects mission support termination.

ACCOMPLISHMENTS AND PLANS

The Mission Control and Data Processing program has pursued proactive measures to consolidate functions, close marginal facilities, and reduce overall contractor workforce to reflect the Agency's goals. Examples include the transition of the EWE MOC operations to TPOCC workstation systems and the outsourcing of these operations to UCB, the completion of SAMPEX science transition to PACOR II, the in-process CGRO transition to TPOCC and PACOR II systems.

Mission control was performed for the HST, CGRO, UARS, EUVE, SAMPEX, FAST, ICE, IMP-8, ERBS, TOMS-EP, XTE, ISTP WIND, POLAR, SOHO, and ACE. The ACE spacecraft was deployed under the control of GSFC mission control facilities. Support was provided to the second HST servicing mission, including the installation of two new sophisticated science instruments and related on-orbit engineering and science checkout.

Packet data processing operations were provided for the HST, CGRO, EUVE, SAMPEX, FAST, SOHO, TOMS-EP, and XTE. The Time Division Multiplexed services were provided for the Geomagnetic Tail, UARS, ERBS, ICE, IMP-8, POLAR, and WIND. Data processing for the Spacelab missions was performed at MSFC. FY 1997 also marked a major ISTP Wind, Polar, SOHO and Geotail reengineering initiative to consolidate systems and operations around a greater use of commercial products to substantially reduce recurring costs, aimed at extending mission life beyond FY 1998.

Flight dynamics services were provided to all NASA space flight missions that utilize NASA's Space Network and to selected elements of the Ground Network, including the Space Shuttle, Expendable Launch Vehicles, and satellite systems. A new operations concept for flight dynamics was developed. The new concept defines an approach to reduce flight dynamics costs by implementing new technology. Attitude software and simulator development was provided for the TRACE, ACE, and TRMM flight systems. Transitioning the FDF to a workstation environment was completed in FY 1997.

Among systems implementation projects, development of TPOCC systems for the TRMM and ACE spacecraft was completed, including the procurenient of workstations, processors, and software. Modifications of the Command Management System effecting workstation deployment to specific MOC's were completed, with CGRO the only residual mission operating on a reduced configuration IBM mainframe. TPOCC development for the EUVE missions was completed and the transition for CGRO continued. The HST Second Servicing completed successfully, with numerous timely flight software and ground system changes effected to accommodate the on-orbit new science instrument operations. The development of innovative spacecraft integration and test and mission operation single system ground support developnient efforts for the MIDEX Microwave Anisotropy Probe (MAP) and MIDEX Imager for Magnetopause to Aurora Global Exploration (IMAGE). and the Small-class Explorer (SMEX) TRACE and WIRE MOC's will be continued.

The spacecraft managed by GSFC's mission control facilities are supported by various NASA communications networks, including the TDRSS, the DSN, the WFF, and transportable ground systems. A wide range of communications and systems interfaces must be managed to accomplish the function of mission control. NASA mission operations personnel support the planning and development of future mission systems and continuous changes to operational spacecraft software systems, as well as the operation of current ground control systems.

Transfer of data systems technologies to flight project use occurred in the areas of software reuse, Very Large Scale lntegration (VLSI) applications, expert system monitoring of spacecraft control functions, and packet data processing systems. Software reuse, expert systems, VLSI user interface, workstation environments, and object-oriented language applications continued. The Mission Control and Data Systems programs will continue to integrate modern technology into mission operations support systems through the use of systems like the Generic Spacecraft Analyst Assistant (GenSAA) for automation, software-based telemetry front-end processing systems and the Mission Operations Planning and Scheduling System, case-based and model-based reasoning tools, and commercial orbit planning systems.

In support of Advanced Technology Development, planning and implementation continued on demonstrating optical laser communications between the ground and an Earth-orbiting spacecraft using the JPL ground facilities and the Japanese ETS-VI satellite. A contract was placed for a 4th-generation, lightweight, low-power-consuming radio transponder for users of the TDRSS.

Conversion of CGRO to TPOCC and PACOR II systems will be completed in FY 1998. The ISTP reengineering systems for mission control and science processing will begin phase-over to Operations. With science processing on EUVE transitioning to UCB, the older PACOR I system will close down in FY 1998. MOC development for TRACE and WIRE will be completed. including the use of these same systems in spacecraft integration and test. MOC developnient for Landsat-7 will be completed, incorporating a commercial state modeling tool to help automate operations. XTE and CGRO operations will incorporate GenSAA and other automation tools to promote reduced shift staffing. Attitude software and simulator development is being provided for the TRACE, WIRE, and TRMM flight systems. The TRMM and TRACE missions will be supported by GSFC's data processing program. The flight dynamics support will complete its transition from the Flight Dynamics Facility at GSFC to the University of Maryland's Flight Dynamics Control Lab in FY 1998. Flight dynamics ground systems will be provided for EOS AM-1, EOS PM-1, and LANDSAT-7, Reimbursable support will be provided to multiple missions, including Geostationary Operational Environmental Satellite (GOES) and National Oceanic Atmospheric Administration (NOAA) programs. Mission planning for future missions such as HST Servicing Missions, Next Generation Space Telescope, EO-2 and EOS will be performed.

Advanced technology initiatives will continue. The 4th generation TDRSS radio transponder engineering unit is underway. Work on deep space radio transponders and data coding technology continues.

Mission Control and Data Systems will provide Mission Control Flight Dynamics and Data Processing service for the TRMM, TRACE and Landsat-7 missions scheduled to be launched in FY 1998. The SAMPEX mission will complete migrating operations to the University of Maryland and Bowie State, and transition of EUVE mission operations responsibilities to the University of California, Berkeley will be completed. Significant development, test, and prelaunch support associated with MIDEX, and the SMEX missions, are part of the Mission Control and Data Systems activity.

Emphasis upon commercial products, artificial intelligence applications and advanced graphical displays will be continued in FY 1998 for application in MIDEX and future SMEX missions. Evolution of systems to a single integrated mission control, command management, flight dynamics, and first-level science processing system will continue. A new Flight Dynamics Facility (FDF) operations concept to perform routine operations as integral functions within mission control centers will be fully implemented in FY 1998. New flight dynamics technology development for autonomous space and/or ground spacecraft navigation and control will be major efforts.

Preparations for the HST Third Servicing Mission will continue, including the delivery of the Vision 2000 ground system, delivery of the new flight control computer flight software, and the payload computer ACS support system. Development efforts will take place in preparation for TRACE, SWAS, WIRE, and MIDEX missions.

The Mission Operations and Data Systems program will focus efforts at operations automation. Mission Control and Data Systems will complete development efforts on the XTE Automated POCC (APOCC) and the CGRO Reduced Operations by Optimizing Tasks and Technologies efforts. Automation will be provided for TRACE to promote single shift staffing for operations. Mission Control and Data Systems will actively lead and participate in establishing new architecture directions and rapid prototyping, exploring system autonomy concepts, and use of commercial-off-the-shelf products.

Mission Control and Data Systems program will continue the lead in scoping and prototyping Mission Operations Control Architecture (MOCA) elements such as: the use of Transmission Control Protocol/Internet Protocol or Space Communications Protocol Standards for ground and flight communications; the use of knowledge-based control languages; ground and space autonomy; and active participation in the American Institute of Aeronautics and Astronautics Spacecraft Control Working Group to infuse emerging operations standards in the areas of satellite control. Exploration of the promise of advanced communications technologies will continue throughout this period.

WIRE, SWAS, IMAGE, and HST SM3 development will be completed in FY 1999. The MSOCC system will be closed. Developments will continue for the MIDEX and SMEX series as well as for the fourth HST Servicing Mission (HST SM4). Development efforts on WIRE, MAP, Imager for Magnetopause-to-Aurora Global Exploration (IMAGE), EO-1, and similar missions will realize benefits from modern technology, commercial products, and niore cost-effective processes (for example, a single system to perform spacecraft integration and test and mission operations; skunkworks development teams; concurrent engineering).

The flight dynamics work will continue to be provided in the areas of ground support system development, analysis, and automation tools. In the area of analysis, work will continue with advanced mission studies needed for pre-phase A efforts, while Phases C and D work will be done to support various EOS, MIDEX, and SMEX missions. The ground systems for those missions will also be developed. Automation efforts will continue in an effort to reduce costs and increase the capability of spacecraft. This will include such items as onboard maneuver planning and station keeping that permits such mission scenarios as formation flying. Additional work will be completed in the area of mission planning tool development that will be in partnership with industry. Throughout all of these efforts, continual process improvement in the areas of analysis and software development will continue to occur with a view toward reducing costs and cycle time and improving quality.

The Advanced Communications Technology Satellite (ACTS) will have completed its period of normal station kept operation and commences a period of extended life operation in an inclined, fuel saving orbit in FY 1998. Reversion to this mode of operation should extend its life by 2 additional years. Continued use of the satellite through FY 2000 will require the use of tracking earth terminals.

The Satellite Alliance USA will become the primary vehicle for collaboratively developing pre-competitive technologies and conducting service enabling demonstrations of mutual benefit to the industry and NASA. One of the initial tasks of the Alliance will be in support of NASA's plans to use commercial communication satellites in support of its operational needs. Other tasks focusing on advanced technologies for future communication satellites have been proposed for consideration by the Alliance. An interactive Web site (http://sat-alliance.lerc.nasa.gov) created in FY 1997 for potential Alliance members is attracting considerable attention. A workshop was conducted in early FY 1998 to solicit interest in membership from industry, universities, and government agencies; and ciiltivate interest in partnerships around initial projects. The Satellite Alliance USA is planned to be formally established in March of 1998.

LeRC assumed implementation responsibility for the Agency's Spectrum Management Program while planning and policy responsibilities were retained at Headquarters in the Office of Space Flight. Efforts in FY 1997 focused on preparations for the 1997 World Radiocommunication Conference (WRC-97). The WRC-97 agenda placed significant emphasis on space science issues for which NASA developed nineteen US proposals to the Conference. Studies were completed to assess sharing feasibility with jointly allocated services. NASA advocated these proposals internationally to the Inter-American Telecommunication Commission. the Space Frequency Coordination Group and at the Conference Preparatory Meeting for WRC-97, as well as at various bilateral and multilateral opportunities involving other administrations. Future WRC agenda items of importance to the Agency were identified and incorporated into the US proposal for future conferences.

The concept of commercially provided direct data distribution (D^3) services from low-Earth orbiting NASA and commercial spacecraft was initiated. Detailed plans for a space-based demonstration using K-band phased array antennas, multichannel broadband moderns, and commercial tracking terminals will be developed. Assembly of a Hitchhiker class flight experiment package will begin, and plans will be developed for insertion of the enabling technologies into International Space Station (ISS) communications upgrades, New Millennium Program Earth Observing 2 (NMP EO-2) spacecraft, and next-generation commercial LEO satellite systems.

The WRC-97 preparatory efforts culminated in early FY 1998. NASA was significantly successful at WRC-97 attaining primary allocation status for 16 of the 19 proposals. Work will continue in preparation for and participation at meetings of the International Telecommunications Union study groups and working groups, NASA will lead a Correspondence Group which will establish sharing criteria for the 26 GHz band, conduct studies to assess sharing in passive microwave sensor bands above 70 GHz, examine the use of Global Positioning Satellite (GPS) system for space navigation, and identify spectrum needed to support future broadband aeronautical telemetry requirements.

The Spectrum Management Program will develop and advocate the Agency proposals for World Radiocommunication Conference-99. Study efforts laying the groundwork for these proposals will be completed and recornmendations formulated within the relevant International Teleconiniunications Union study groups and working parties.

BASIS OF FY 1999 FUNDING REQUIREMENT

SPACE NETWORK CUSTOMER SERVICES

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Space Network Customer Services	25,900	31,100	27,300

PROGRAM GOALS

The Space Network Customer Service program goal is to provide high quality, reliable, cost-effective customer access to the multi-mission space telecommunications network serving all TDRS-compatible Earth orbiting and suborbital flight missions and to provide network control and scheduling services to customers of both the Space Network and selected Ground Networks elements.

STRATEGY FOR ACHIEVING GOALS

This program develops and maintains both the management and technical interfaces for customers of the Space Network. The Network Control Center (NCC), located at the Goddard Space Flight Center in Maryland, is the primary interface for all customer missions. The primary function of the NCC is to provide scheduling for customer mission services. In addition the NCC generates and transmits configuration control messages to the network's ground terminals and TDRS satellites and provides fault isolation services for the network. The Customer Services program also provides comprehensive mission planning, user communications systems analysis, mission analysis, network loading analysis, and other customer services and tests to insure network readiness and technical compatibility for in-flight communications.

The AlliedSignal Technical Services Corporation and the Computer Sciences Corporation are the primary support service contractors responsible for systems engineering, software development and maintenance, operations, and analytical services. The two contractors established a voluntary partnership in 1996 for these services under the CNMOS performance based contract.

The Customer Services program also undertakes network adaptations to meet specific user needs and provides assistance to test and demonstrate emerging technologies and communications techniques. A low power, portable transmit/receive terminal, called Portcom, which operates with TDRS spacecraft has been demonstrated. Potential applications include data collection from remote sites where commercial capabilities do not exist, such as NOAA ocean research buoys and National Science Foundation (NSF) Antarctic activities. A series of tests are being conducted with Japanese and European satellites and data acquisition systems. These will explore interoperability of the NASA Space Network and the National Space Development Agency (Japan) (NASDA)/ESA communications systems for mutual provision of emergency operational spacecraft support.

MEASURES OF PERFORMANCE

	FY 1997		FY 1998		FY 1999
	plan	Actual	plan	Current	plan
Number of NASA spacecraft events supported by the NCC	61,000	57,100	74,400	80,900	98,000

The FY 1997 number of NASA Spacecraft events supported by the NCC will remain fairly stable until the FY 1998 additions for support of Landsat-7, TRMM, ETS-VII,, EOS AM-1, and Space Station assembly activities. The FY 1999 increase is due to the anticipated full-up support of the ISS mission.

ACCOMPLISHMENTS AND PLANS

Implementation was continued on an improved, distributed architecture for the NCC. When completed, this modification will provide more efficient use of the network capabilities, improved ability to resolve scheduling conflicts among customer missions, and provide standard commercial protocols for both internal and customer interfaces. This architectural change will be undertaken over several years and accomplished segment by segment. The segment of the control center to be modified first is the service scheduling system.

The NCC modifications to the scheduling system continued including incorporation of standard commercial protocols and the Request Oriented Scheduling Engine (ROSE) which provides special features for conflict-free spacecraft scheduling, such as goal-directed scheduling and repetitive activities with variable start limes and durations. The development of a compact transponder, using new technology, suitable for use by new, small satellites was continued. This dual award procurement will provide engineering models and a small number of flight units from both Cincinnati Electronics and Motorola. These small satellite transponders expand Space Network/TDRS use to a new class of missions. A contract was initiated to design and develop a Ka-Band Phased Array Antenna. This system will enable Low Earlh Orbiting (LEO) spacecraft to establish high data rate communications in the Ka frequency band, either to ground stations or via TDRSS-H, I, J.

The Space Network Custonier Services program will provide for continued operations, maintenance, and modification of the NCC. The scheduling system modification will be completed and become operational. The communication and control segment modification effort will be initiated. This segment modification will complete the distributed architecture modifications and lower the life cycle cost of the Network Control Center.

The Service Planning Segment Replacement project will become operational in late FY 1998 in the Space Network Control Center (NCC). This will start the implementation of the Network Control Center Data System into a workstation, Unix-based environment, resulting in an estimated 40 percent reduction in life cycle costs. Development of a fourth generation TDRS spacecraft communications system for use by small satellites will near completion; development efforts for the Ka-Band Phased Array Antenna will continue.

The requested funding also provides for continuation of mission planning, customer requirements definition and documentation, mission and network operational analyses, customer communications systems analyses, lest coordination and conduct, and other customer support services. An interoperability demonstration with the TRMM spacecraft and a Japanese data relay satellite precursor, Communications and Broadcasting Engineering Test Satellite (COMETS), will be conducted. Compatibility testing will be planned for TRMM, Landsat-7, EOS AM-1, International Space Station, WIRE, and upcoming National Oceanic and Atmospheric Administration (NOAA) missions in FY 1998. Simulations, engineering tests, and data flows will be conducted to verify communications designs and train mission control operators.

The Space Network Customer Services program will provide for continued operations, maintenance, and modification of the NCC. The communication and control segment modification effort will continue. The Communications and Control Segment Replacement project will begin in the Space Network Control Center (NCC) and will allow the completion of the implementation of the Network Control Center Data System into a workstation, Unix-based environment, resulting in an estimated 50 percent reduction in the amount of application code and a reduction in life-cycle cost. The fourth generation TDRS transponder will be available in early FY 1999; development efforts on the Ka-Band Phased Array Antenna will near completion.

Academic Programs

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
Education	65,600	68,600	54,100	SAT 6.1-1
Minority research and education	54,800	51,400	45,900	SAT 6.2-1
Total	120,400	120,000	100,000	

Education Programs

SCIENCE AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS — **EDUCATION PROGRAMS**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999	Page Number
		Thousands of Dollars)		
Student support programs	10.000	9.400	8.600	SAT 6.1-6
Teacher/faculty preparation and enhancenient programs	14.000	13.400	12.800	SAT 6.1-10
Support for systemic change	24.800	29.900	24.300	SAT 6.1-14
Educational technology	16.100	15.200	7.700	SAT 6.1-19
Evaluation	700	700	700	SAT6.1-23
Total	65,000	68,600	54,100	

Distribution of Program Amount by Installation

	FY 1997	FY 1998	FY 1999
Johnson Space Center	1.600	1.300	1.300
Kennedy Space Center	800	800	800
Marshall Space Flight Center	3.100	2.900	2.800
Stennis Space Center	1.100	900	900
Ames Research Center	2.600	4.500	3.900
Langley Research Center	500	500	500
Lewis Research Center	1.300	1.200	1.200
Dryden Flight Research Center	2.000	1.100	1.100
Goddard Space Flight Center	40.900	44.300	30.800
Jet Propulsion Laboratory	1.700	1.500	1.400
Headquarters	10.000	9.600	9.400
Total	65,600	68,600	54,100

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 1999 ESTIMATES

ACADEMIC PROGRAMS **EDUCATION PROGRAMS**

PROGRAM GOALS

NASA's vision for education is set forth in the NASA Strategic Plan as one of the four strategic outcomes for the agency:

> *To promote the pursuit of educational excellence by involving "the educational cornrnwiity in our endeavors to inspire America's students, create learning opportunities, and enlighten inquisitive minds."*

This outcome is accomplished through implementation of a full range of NASA education programs which contribute to the various efforts and activities of those involved with and in the education community, and benefit the participants as well as advance the mission of the agency.

STRATEGY FOR ACHIEVING GOALS

In carrying out its education programs, NASA is particularly cognizant of the powerful attraction the NASA mission holds for students and educators. The unique character of NASA's exploration, scientific, and technical activities has the ability to captivate the imagination and excitement of students and teachers, and channel this into education endeavors which support the National Education Goals, specifically to make American students first in the world in science and mathematics achievements.

In fulfilling its role to support excellence in education as set forth in the NASA Strategic Plan, the NASA Education Program brings students and educators into its missions and its research as participants and partners. NASA provides the opportunity for teachers and students to experience first hand involvement with NASA's scientists and engineers, its facilities, and research and development activities. The participants benefit from the opportunity to participate in research and development endeavors, gain an understanding of the breadth of NASA's activities, and return to the classroom with excitement to share with the entire education community. NASA contributes to promoting excellence in education by sharing access and involvement in the NASA mission. Underpinning the entire Education Program is the commitment to involve participants from diverse and underrepresented populations in the science, mathematics and technology pipeline.

NASA remains an involved member of the National Science and Technology Council (NSTC)/Committee on Education and Training (CET). NASA's education activities are fully supportive of the NSTC Education Strategic Plans and the National Education Goals, three of which relate to mathematics and science education.

NASA's Strategic Plan for Education

In 1993, NASA issued its first education strategic plan, NASA's Strategic Plan for Education: A Strategy for Change: 1993- 1998. This roadmap set forth a comprehensive process to redirect and change the focus of the NASA Education Program. The key goals for NASA's Education Program are:

- To maintain that segment of NASA's current education program -- hereinafter referred to as the base or core program -- that is judged to be effective, based on internal and external customer measures of success. Such maintenance involves individual program revision, expansion, or elimination.
- To implement new education reform initiatives which specifically address NASA mission requirements, national education reform, and NSTC priorities.
- To significantly expand the impact of the NASA education program by developing partnerships with external constituencies.
- To articulate, develop, and implement a NASA education program and evaluation framework.

These goals are supported by enabling activities and management priorities to guide the change process. Since its publication, all NASA field centers and many enterprises have developed center/enterprise-specific strategic plans that are aligned with and support the agency plan for education. The agency is currently revising this plan, with an expected publication date in FY 1998.

PROGRAM PERFORMANCE MEASURES

In 1994, NASA commissioned the National Research Council (NRC)to prepare a comprehensive set of recommendations for the organization and definition of these goals and enabling systems in accord with the management priorities that had been articulated. The NRC report, NASA's Education Programs: Defining Goals and Assessing Outconies recommended a set of categories for integrating NASA's education goals with the mission of the agency and established the foundation for a solid evaluation program. Working with the NRC recommendations and the principles set forth in the NASA Education Strategic Plan, an agency framework for education programs and evaluation was established in 1994,

This framework integrates NASA's education programs, which touch the entire range of the education "customer"community, with the programmatic activities of NASA's Enterprises. Each category identifies a goal which reflects its role in relationship to the NASA mission, and is supported by performance measures for evaluation. These categories are:

- Student Support

Goal: To use the NASA mission, facilities. human resources and programs to provide information, experiences, and research opportunities for students at all levels to support the enhancement of knowledge and skills in the area of science, mathematics, engineering and technology.

- Teacher/Faculty Preparation and Enhancement

  Goal: To use the NASA mission, facilities, human resources, and programs to provide exposure and experiences to teachers and faculty to support the enhancement of knowledge and skills, and to provide access to NASA information in science, mathematics, technology, and engineering.

- Support for Systemic Change

  Goal: To use NASA's unique assets to support local, state, regional and national mathematics, science, engineering, and technology education change efforts through collaboration with internal and external stakeholders.

- Curriculum Support and Dissemination

  Goal: To develop, utilize and disseminate science, mathematics, geography, and technology instructional materials based on NASA's unique mission and results, and to support the development of higher education curricula.

- Educational Technology

  Goal: To research and develop products and services that facilitate the application of technology to enhance the educational process for formal education and lifelong learning.

During FY 1997, NASA has refined and implemented the framework and the evaluation system which was pilot tested in FY 1996. The evaluation strategy was also updated to meet the requirements of the Government Performance and Results Act. For each of the five categories and goals listed above, several objectives were defined. Subsequently, one or more evaluation questions were developed for each objective. This resulted in a common core of evaluation items and data which is being used to evaluate all programs within a category. EDCATS, an innovative networked data base, has been developed to collect and analyze these data.

Additionally, certain programs conducted more detailed evaluation studies in FY 1997, designed to analyze progran-specific objectives in a detailed and systematic manner. These in-depth studies, which include qualitative data reviews, also allow program managers to probe deeper into programmatic issues than can be done solely through the collection of quantitative data and make appropriate program modifications.

In FY 1997, several evaluations of NASA's major national education programs were initiated. These programs included: NEWMAST/NEWEST, Spacelink, the Educator Resource Center Network, the Space Science Student Involvement Program, and the Space Grant College and Fellowship Program. In each case, independent, third-party reviewers were included and program modifications were made **if** necessary.

BASIS OF FY 1999 FUNDING REQUIREMENT

STUDENT SUPPORT PROGRAMS

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Elementary and secondary	2,800	2,600	2,200
Higher education	7,200	6.800	6,400
Total	10,000	9,400	8,600

PROGRAM GOALS

The goals of the Student Support Programs are: to use the NASA mission, facilities, human resources, and programs to provide information, experiences, and research opportunities for K- 12, and undergraduate and graduate students to support the enhancement of knowledge and skills in the areas of science, mathematics, engineering, and technology.

STRATEGY FOR ACHIEVING GOALS

Elementary and Secondary

At the elementary and secondary level, student support activities provide (a) programs which utilize the NASA mission, facilities, and resources; (b) experiences and information that are designed to promote student interest in mathematics, science, engineering and technology; and (c) exposure to research and/or research experiences to promote mathematics, science, engineering and technology awareness. Activities such as the Space Science Student Involvement Program (SSIP) and the Shuttle Amateur Radio Experiment (SAREX) provide general exposure to NASA's mission and stimulate interest in mathematics, science, and technology subject matter. Additional activities such as the Summer High School Apprenticeship Research Program (SHARP and SHARP-PLUS), demonstrate the applications of mathematics, science and technology by providing research experiences for students who traditionally have not been represented in mathematics, science and engineering fields.

Higher Education

At the higher education level, student support activities provide undergraduate students exposure to and involvement in research activities; provide experiences that facilitate transition from undergraduate work to graduate studies in NASA-related areas; support students to pursue graduate studies in NASA-related areas: and facilitate continuing professional development and contributions to research in NASA-related disciplines. At the higher education level, activities such as the Graduate Student Researchers Program (GSRP) provide support to train students in NASA-related disciplines at both the master's and doctoral levels.

MEASURES OF PERFORMANCE

	FY 1997 Plan	FY 1997 Actual	FY 1998 plan	FY 1998 Revised	FY 1999 plan
Elementary and secondarv					
Space Science Student Involvement Program					
-- Students *	11,000	11,000	11,000	11,000	11,000
-- Entries/proposals	9,000	8,100	9,000	8,100	8,100
-- Teacher participants	1,200	1,600	1,600	1,600	1,600
-- Schools	N/A	778	N/A	775	775
-- National awards	14	26	14	26	26
-- States participating	N/A	50	N/A	50	50
SHARP/SHARP-PLUS					
-- Student participants *	500	491	500	425	425
SAREX					
-- Student participants *	10,000	10,000	10,000	10,000	10,000
Higher education					
Graduate Student Researchers Program					
-- Student participants	510	430	436	400	400
-- Universities	117	120	110	110	110
-- States participating	N/A	50	N/A	50	50

* Number of participants is estimated

Currently, program activities in the above categories have a variety of evaluation mechanisms. In FY 1998, a high priority activity will be to further develop and implement key indicators as standards by which all program activities will be measured. These could include such outcomes as career aspirations/awareness, educational aspirations; participation in research activities; persistence to undergraduate or graduate degree: career path: career productivity; participation in other NASA programs and increased participation of underrepresented groups. NASA's Education Evaluation System (EDCATS) will become fully operational, providing for the collection, analysis, evaluation, and reporting of student support program data and program outcomes throughout the NASA system.

ACCOMPLISHMENTS AND PLANS

Elementary and Secondary

The student support programs implemented to provide experiences and exposure to NASA's mission are: SHARP/SHARP-PLUS, SSIP and SAREX. These are a series of programs that capture interest in mathematics, science, engineering, and technology. and channel that interest into mathematics, science, engineering, and technology career paths.

In FY 1997, the SHARP/SHARP PLUS program involved 491 underrepresented minority high school students in intensive research apprenticeships with NASA, industry, and university scientists and engineers. *SHARP* students live within commuting distance of a NASA installation; SHARP PLUS students have residential research experiences at a participating Historically Black College or University or a Predominately Minority Institution. The goal of both programs is to involve students from groups traditionally underrepresented in science, mathematics, engineering, and technology in a research environment. In FY 1998, enrichment opportunities will be explored, such as greater involvement in community service projects, and greater opportunities to link these students with undergraduate and graduate opportunities will be pursued. In FY 1999, the Elementary/Secondary student programs will continue at a slightly reduced level due to anticipated budget reductions.

The Space Science Student Involvement Program (SSIP) is another program managed in collaboration with the National Science Teachers Association, National Council of Teachers of Mathematics, and the International Technology Education Association, that promotes literacy in science, mathematics, and technology among U. S. students in grades 3-12. In FY 1997, more than 1,600 teachers and 11,000 students participated in and entered contests that demonstrated the students' skills in science as well as art, graphics, and writing. By FY 1998 the program will be redesigned to insure closer linkages with the NASA enterprises. In FY 1999, the program will continue in its redesigned state, but at a slightly reduced level due to a projected budget decrease.

The Shuttle Amateur Radio Experiment (SAREX) provides students the opportunity to participate directly in the Shuttle program through the use of technology. Through actual communication with Shuttle astronauts via amateur radio, and supporting activities, students gain first-hand knowledge of the Shuttle program and its science objectives. SAREX is a mid-deck payload on the Shuttle, and was manifested on 2 flights in FY 1997, involving 18 schools in direct contact with Shuttle astronauts . This program is accomplished in collaboration with the American Radio Relay League's extensive volunteer network and involves more than 10,000 students per mission, worldwide. The program is expected to include approximately the same number of students in FY 1998 and FY 1999.

Higher Education

At the higher education level, the GSRP, initiated in 1980, provides graduate fellowships nationwide to post-baccalaureate U. S. citizens to conduct thesis research. Awards are made to graduate students for a maximum of three years. On an annual basis, NASA supports approximately 400 graduate students pursuing masters or doctorate degrees in areas compatible with NASA's programs in Earth/space science, aeronautics, and aerospace technology. The request in FY 1998 will maintain the fellowships close to the current level. In addition, linkages will be explored with programs at the precollege level, such as SHARP/SHARP-PLUS, in an effort to broaden the participation of all students in mathematics, science, engineering, and technology fields. The program will continue in FY 1999 at approximately the same level as FY 1998.

BASIS OF FY 1999 FUNDING REQUIREMENT

TEACHER/FACULTY PREPARATION AND ENHANCEMENT PROGRAMS

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Elementary and secondary	5,000	4,700	4,200
Higher education	9,000	8,700	8,600
Total	14,000	13,400	12,800

PROGRAM GOALS

The goal of the Teacher/Faculty Preparation and Enhancement Programs is to use the NASA mission, facilities, human resources and programs to provide exposure and experiences to teachers and faculty to support the enhancement of knowledge and skills, and to provide access to NASA information in science, mathematics, technology, and engineering.

STRATEGY FOR ACHIEVING GOALS

Elementary and Secondary

At the elementary and secondary level, preparation and enhancement activities are designed to utilize the NASA strategic enterprises and the process by which new knowledge is discovered to demonstrate the application of mathematics, science and technology in student learning; enhance teachers' capability to design lessons and experiences that use scientific inquiry to affect student learning: encourage a "multiplier" effect to extend the benefits of the in-service program beyond participants to other teachers and students; and provide access to and promote utilization of NASA related materials and information resources. Pre-service programs such as Project NOVA, and in-service programs such as NASA Education Workshops for Elementary School Teachers (NEWEST), NASA Education Workshops for Math, Science, and Technology Teachers (NEWMAST), and Urban Community Enrichment Program (UCEP) are designed to enhance and improve the teaching of mathematics, science, and technology by denionstrating their applications in aeronautics and space through workshops around the country. The Teaching From Space Program continues to provide instructional products that help support these preparation and enhancement workshops.

Higher Education

At the higher education level, activities are designed to enhance faculty research skills and content knowledge; balance participation so that a cross-section of colleges and universities is represented (i.e., community colleges, four year institutions, institutions that serve significant numbers of underrepresented groups, underfunded institutions); and provide opportunities for curriculum expansion/revision that aligns with the mission needs of NASA and universities. At the higher education level, activities such as the Summer Faculty Fellowship Program (SFFP) and the NASA/University Joint Venture (JOVE) Program provide research experiences for faculty at NASA field centers to further their professional knowledge in the engineering and science disciplines, and to ultimately enhance the undergraduate/graduate curriculum.

MEASURES OF PERFORMANCE

	FY 1997		FY 1998		FY 1999
	plan	Actual	plan	Revised	Plan
Elementary and secondary					
Project NOVA					
-- University teams	N/A	33	30	40	40
-- Teacher participants	N/A	100	95	160	160
NEWEST/NEWMAST					
-- Teacher participants	250	225	210	410	450
STEP					
-- Teacher participants	N/A	300	285	*	*
UCEP					
-- School districts	N/A	103	N/A	90	90
Higher education					
Summer Faculty Fellowship Program					
-- Faculty participants	275	314	260	260	260
-- Colleges/universities	170	195	160	160	160
JOVE					
-- Faculty participants	263	151	175	125	125
-- Colleges/universities	130	140	85	125	125

*** STEP combined with NEWEST/NEWMAST program**

Teaching from Space

- 3 Educational videotapes with resource guides
- Instructional products with activities: Rockets teachers guide (physical sciences); Microgravity teachers guide (mathematics); Meteorites teachers guide (earth/space science); teachers and students investigating plants in space (life sciences); solar system lithograph set: cooperative ventures with Young Astronaut Council (earth sciences) and the National Council for Teachers of Mathematics (mission mathematics).
- Educator Resource Center Network : 150,943 educators used the ERCN (visits, mail, phone, email) at 73 locations in 47 states - 192,709 multimedia products distributed; 1,24 1,074 publications/lesson guides distributed

Currently, program activities in the above categories have a variety of evaluation mechanisms. In FY 1998, these evaluation mechanisms will incorporate such outcomes as career aspirations/awareness, educational aspirations; participation in research activities: persistence to undergraduate or graduate degree; career path; career productivity: participation in other NASA programs; and increased participation of underrepresented groups. NASA's Education Evaluation System (EDCATS) will become fully operational, providing for the collection, analysis, evaluation, and reporting of teacher/faculty preparation and enhancement program data and program outcomes throughout the NASA system.

ACCOMPLISHMENTS AND PLANS

Elementary and Secondary

By targeting educators as part of NASA's education strategy, programs such as Project NOVA, NEWEST/NEWMAST, STEP, UCEP, and Teaching from Space, play a significant role in ensuring that students and educators alike are provided today with the tools they will need tomorrow. Teacher preparation programs such as Project NOVA disseminate nationally an undergraduate pre-service model based on standards and benchmarks for science, mathematics, and technology. Teacher enhancement programs provide opportunities for in-service teachers to update their backgrounds and skills in science, mathematics, and technology. NEWEST/NEWMAST provides a leadership opportunity for 240 outstanding teachers: and UCEP provides more than 475 urban teachers greater exposure to new NASA knowledge. Using multiple formats, Teaching From Space develops products that are incorporated into enhancement activities, providing tools that can be applied in the classroom and disseniinated through the Teacher Resource Center Network.

Since both STEP and NEWEST/NEWMAST have similar program objectives, in FY 1998 they will be combined into one set of programs, the NASA Education Workshops, to better utilize resources and meet overall teacher/faculty preparation and enhancement program objectives.

The impact of slightly reduced funding levels in FY 1998 will be evidenced by slightly lower participation rates in workshops or in a reduced number of workshop opportunities. In an effort to reach a broader population, UCEP programs will be conducted in Prince Georges County, MD; Hartford, CT; Newark, NJ; Lafayette, LA; and Los Angeles, CA. In FY 1999, the budget is projected to remain at FY 1998 levels, and programs will continue as planned.

Higher Education

The Summer Faculty Fellowship Program provides highly beneficial opportunities for U. S. citizen engineering and science faculty throughout the Nation to participate in NASA research. This program has contributed significantly to the improvement of both undergraduate and graduate education, and directly benefits NASA, universities, faculty, students and the Nation. Approximately 300 university faculty are supported annually for ten weeks. Evaluations of the program, conducted by the American Society for Engineering Education (ASEE) indicate that approximately 30-40% of the participating faculty subsequently receive NASA research grants or contracts

The Joint Venture (JOVE) Program also provides opportunities for college and university faculty to come to NASA centers to work with NASA data and to enhance research and teaching capabilities. JOVE is managed by the Marshall Space Flight Center, where it was initiated as a pilot program in FY 1989. NASA provides scientific on-line data from space missions, as well as support for electronic work stations and partial faculty and student support. In turn, the universities agree to grant faculty release time, provide student support, and develop an instructional unit on a space science topic. There are currently 140 academic institutions participating, most of whom had little previous contact with the agency.

Since both SFFP and JOVE have similar objectives, i.e., to enhance the research and teaching capabilities of individual faculty members and their institutions, these programs will be reviewed in FY 1998. It is NASA's intent to lake the best of both programs -- center research opportunities of SFFP and follow-on opportunities of JOVE -- and create a new program that would begin in FY 1999.

BASIS OF FY 1999 FUNDING REQUIREMENT

SUPPORT FOR SYSTEMIC CHANGE

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Aerospace Education Services Program (AESP)................................	6,100	5,600	5,600
National Space Grant College and Fellowship Program.....................	13,600	19,100	13.500
Experimental Program to Stimulate Competitive Research.,.............	4,500	4,600	4,600
Innovative Reform Initiatives..	600	600	600
Total	24,800	29,900	24,300

PROGRAM GOALS

The goal of the Support for Systemic Change Program is to support local, state, regional, and national efforts to enhance the goals of the educational community through individual or collaborative efforts with a range of partners.

Systemic change encompasses the process whereby an entire system is re-engineered toward achieving a new goal. As an example, a superintendent's agenda for change in the public schools might include: school based management; curricula changes to support state standards; increased teacher enhancement support; inclusion of technology access and use by all students; or creation of new student assessment systems. NASA is committed to supporting systemic initiatives in the areas of science and mathematics education. and its activities vary depending on the needs of the institution. Thus, the activities supported by programs included in this category seek to provide a range of support in response to the needs of the customer community

STRATEGY FOR ACHIEVING GOALS

Elementary and Secondary

Support for Systemic Change activities at the elementary and secondary level use NASA personnel and resources to contribute to K-12 mathematics, science, and technology education reform by promoting the involvement of various community sectors: and target a cross-section of schools and organizations which serve a variety of participants, including those from underrepresented groups. A major program at the elementary and secondary education level is the Aerospace Education Services Program (AESP). The AESP's primary focus is teacher enhancement with emphasis on and support for local, state, regional and national mathematics, science, and technology education reform efforts through collaboration of internal and external stakeholders in high impact reform activities.

Higher Education

Support for Systemic Change activities at the higher education level uses partnerships, linkages, and collaborations to provide activities and experiences designed to enhance research and educational capabilities, and enhance the collaborative capabilities of a diverse set of academic institutions. Progranis such as Space Grant and EPSCoR play a major role in NASA's contribution toward the Nation's systemic educational reform movement.

The Space Grant Program was authorized by Congress in 1987 to increase the understanding, assessment, development, and use of space resources. All 50 states, Puerto Rico, and the District of Columbia have Space Grant Consortium programs in which 670 institutions participate. These consortia forni a network of colleges and universities, industry, state/local governments, and nonprofit organizations with interests in aerospace research, training, and education.

The FY 1993 NASA Authorization Act (P.L. 102-588) directed NASA to initiate a program to strengthen the research capability of states that do not successfully participate in competitive space and aeronautical research activities. The NASA EPSCoR Program, modeled after the National Science Foundation's EPSCoR, provides seed funding that will enable eligible states to develop an academic research enterprise directed toward long-term, self-sustaining, nationally competitive capabilities in space science and applications, aeronautical research and technology, and space research and technology programs. This capability will, in turn, contribute to the state's economic viability.

Systemic change at both elementary and higher education levels is captured in NASA's Innovative Reform Initiatives program which is supportive of standards-based systemic reform efforts and NSTC/CET priorities, and focuses on science, mathematics and technology education. A nieans of accomplishing systemic reform is through partnerships with professional education associations, national aerospace education associations, industries, other Federal agencies, and state and local groups. When NASA becomes a partner with these groups, its role may be one of leadership, being a participant, or acting as a facilitator to empower and enable wide reaching educational reform that is systemic in nature. An example of these partnerships is NASA's work with the National Alliance of State Science and Math Coalitions (NASSMC).

MEASURES OF PERFORMANCE

	FY 1997		FY 1998		FY 1999
	plan	Actual	plan	Revised	plan
AESP					
-- Schools visited	400	1062	365	1,000	900
-- Teacher workshops	2,000	1,903	2,000	1850	1,800
-- Teacher participants	21,000	19,818	19,300	19,300	19,000

Space Grant

- 52 University-based Consortia
- Space Grant involves 643 institutions which include:
  - 429 colleges and universities
  - 78 business/industry
  - 31 State and local government agencies
  - 105 other affiliates (science museums, not for profits, etc.)
- 9,900 fellowships and scholarships (66% undergraduate; 21% underrepresented groups: 38% women)
- 786 education programs/projects/activities
- 756 public service programs/projects/activities

	FY 1997 plan	FY 1997 Actual	FY 1998 plan	FY 1998 Revised	FY 1999 plan
EPSCoR					
-- Awards	10	6	10	10	10
-- Institutions	55	55	55	68	68

- Awards to ten states:
  - Alabama, Arkansas, Kentucky, Louisiana, Montana, Puerto Rico – original awardees
  - Kansas, Nebraska, Oklahoma, South Carolina - new in 1996
- Participants:
  - Institutions: 68
  - Research clusters: 48
  - Faculty: 244
  - Post doctoral fellowships: 38
  - Graduate students: 219
  - Undergraduates: 154

Currently, program activities in the above categories have a variety of evaluation mechanisms. In FY 1998, a high priority activity will be to further develop and implement key indicators as standards by which all program activities will be measured. These could include such outcomes as the establishment of partnerships, increased resources, proposals submitted, proposals funded, papers in peer reviewed publications, presentations to professional societies, and new ways of conducting business. NASA's Education Evaluation System (EDCATS) will provide for the collection, analysis, evaluation, and reporting of support for systemic change program data and program outcomes throughout the NASA system.

ACCOMPLISHMENTS AND PLANS

The Systemic Change programs address many different levels within the education community and include AESP, Space Grant, EPSCoR and Innovative Refomi Initiatives.

The AESP has been redirected to an emphasis on teacher enhancement, so that specialists are now directly involved in supporting state systemic reform by providing technical linkages to NASA research and development and education programs and services. The AESP delivers educational services on a state-by-state basis. Each education specialist is assigned one or two states so they might become familiar with their states' science, mathematics, and technology frameworks and the education leaders within these states. This enables them to customize or tailor-make their teacher workshops to fit that particular state's framework. Funding in FY 1998 and FY 1999 will continue operation of this program, although projected reductions will result in fewer teacher workshops conducted around the country.

In FY 1998, funding was increased pursuant to Congressional direction in P.L. 105-65. This funding increase will provide for increased basic awards for all Space Grant consortia in FY 1998, and support award of designation status to up to three additional state consortia, These will be the first increases in the basic awards for the Space Grant consortia since the program's inception. Since there have been no inflationary adjustments over the years, the increases will enable the consortia to continue with elements of their program plans that have been deferred due to lack of growth in the program funding levels

FY 1997 marked the fourth year of the NASA EPSCoR program with continued funding for the original six awardees. These six states have been very successful in a short period of time, producing 152 papers in peer-reviewed media, 182 papers/abstracts in progress, $25.6M in additional research grants and $19.2M in pending proposals. In addition, four new states were chosen in the second round of awards in late FY 1996 (Kansas, Nebraska, Oklahoma, South Carolina). They are completing their first year of work, and are expected to be as successful as the first group. Funding planned for FY 1998 will maintain the current group of awardees. A new solicitation of awardees is planned for FY 1999.

NASA's Innovative Refomi Initiatives program supports standards-based systemic reform efforts and priorities, and focuses on science, mathematics and technology education. To prevent duplication and to strengthen the impact of systemic reform initiatives, NASA confers with other federal agencies and nalional organizations that are also working with educational systemic reform, including the National Science Foundation, U.S Department of Education, National Research Council, Council of Chief State School Officers, the Smitlisonian Institution and professional education organizations such as the National Science Teachers Association, National Council for the Teaching of Mathematics, and the International Technology Education Association. Systemic reform initiatives are accomplished through partnerships with local, state, and national stakeholders including professional education associations, national aerospace education associations, industries, education agencies, and other interest groups. When NASA becomes a partner with these groups, its role varies between providing supportive leadership, being a complementary participant, or acting as a facilitator to empower and enable wide reaching educational reform that is systemic in nature. Examples of these partnerships are the National Alliance of State Science and Math Coalitions (NASSMC), the Council of State Science Supervisors (CS3), the NASA Industry Education Initiative (NIEI), the Tri-State Education Initiative (TSEI), and the Aerospace Education Alliance.

These partnerships are each mutually beneficial in creating systemic change by increasing the customer and support bases for both NASA and the partnering stakeholder. Similar opportunities will be explored in FY 1998 and FY 1999.

NASA's Education Division held a conference in late calendar year 1997, in partnership with NASSMC, entitled "Building Infrastructure for State-Level Reform." This conference brought together NASA principal investigators, education, science and mathematics coalition leaders from throughout the United States to focus on systemic change at the state level. The Division also held a meeting in late calendar year 1997 with selected members of the NASA Industry Education Initiative. The goal of NIEI is to focus the collective efforts of NASA and its corporate partners to achieve the national education goals and to support NASA's Strategic Plan for Education. The purpose of the meeting was to update the NIEI members on NASA's strategy to support mathematics, science, and technology education reform including NASA's effort to transition from one national education program into initiatives that are designed to address state needs and to support each state's reform effort.

BASIS OF FY 1999 FUNDING REQUIREMENT

EDUCATIONAL TECHNOLOGY

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Learning tools	2,000	1,700	1.900
Demonstrations	2,000	2,000	1,800
HPCC	1,400	4,200	4,000
Museum Initiative/American Museum of Natural History	8,000	--	--
Upgrades to Mobile Aeronautics Education Lab	300	--	--
Feasibility Study, National Residential High School, LeRC	250	--	--
Replication of Science, Engineering, Mathematics and Engineering Academy (SEMMA)	300	--	--
Classroom of the Future, Astronomy Village	300	--	--
Bishop Museum/National Prototype Space Education Curriculum	1,600	1,000	
Alaska Learning Center	--	1,300	--
Apple Valley, California Learning Center	--	800	--
K- 12 Telecommunications	--	2,000	--
Louisiana Daily Living Center	--	1.000	--
Pennsylvania Education Telecommunications Center	--	700	--
California Discovery Science Center	--	500	--
Total	16,200	15,200	7,700

PROGRAM GOALS

The goal of the Educational Technology program is to research and develop products and services that facilitate the application of technology to enhance the educational process for formal education and lifelong learning.

STRATEGY FOR ACHIEVING GOALS

The Educational Technology program researches, develops, and disseminates technology to support new models of teaching and learning for teachers and students. The teaching and learning tools developed through this program combine the unique NASA mission and innovative technology and networking applications to stimulate student interest and achievement in mathematics, science, and technology. Educational Technology activities produce teaching tools (e.g., Internet services, CD-ROM databases, live or taped video, computer software, multimedia systems, virtual reality) and supplementary instructional materials. These tools use knowledge derived from NASA research and existing technology as well as emerging technologies to facilitate education programs which support the state and local mathematics, science, and technology initiatives. Demonstrations of high-quality, efficient, and effective technology and networking applications are supported

The NASA Classroom of the Future (COTF) continues to be the major component of the educational technology program. The role of the COTF is to translate NASA technologies and research results into learning tools, demonstrations, and teacher enhancenient programs which support standards-based education reform.

The Center-based K-12 Internet Initiative, which is part of the HPCC program, provides demonstration projects and on-line systems dedicated to bringing real NASA science to teachers and students in the classroom, using examples from NASA's unique missions. The goal of this program is to accelerate the implementation of a national information infrastructure through NASA science, engineering, and technology contributions and facilitate the use and technologies of the infrastructure within the K-12 education systems. NASA, led by Ames Research Center, organizes various interactive on-line projects that connect classrooms with ongoing science and engineering work. The projects provide real and relevant content to enhance classroom curriculums.

MEASURES OF PERFORMANCE

- **Educator Resource Center Network** : 150,943 educators used the ERCN (visits, mail, phone, email) at 73 locations in 47 states;
  192,709 multimedia products distributed; 1,241,074 publications/lesson guides distributed

- NASA **Spacelink:** 20,069,700 www hits; 188.8GB of data transferred; 910,777 unique internet addresses: 250,000 NASA www pages: 13,000 documents on line.

- **CD-ROM** for science education: SIR-C, TOPEX/POSEIDON, and NASA Scatteronieter projects; The Heart in Space

- Research and development: **Classroom of the Future**

- **Learning Technologies Program** (Information Infrastructure Technology and Applications): 18,250,000 web page hits: 149 instructional support products produced

ACCOMPLISHMENTS AND PLANS

Educational Technology activities support the development of high quality, affordable learning tools and environments (e.g., CD-ROM databases, DVD-ROM, live or taped video, computer software, multimedia systems, virtual reality) and supplementary instructional materials. These tools use existing technology as well as emerging technologies to facilitate education programs. Demonstrations of innovative, efficient, and effective technology and networking applications are also supported. Classroom of the Future continues to be NASA's primary educational technology research and development site.

NASA's Educational Technology program includes the center-based components of the High Performance Computing and Communications/Learning Technologies Program (HPCC/LTP). One of the goals of this prograni is to demonstrate how newly emerging communication technologies can be used to bring NASA's science and engineering data to schools and the public. The ten center-based projects have made extensive amounts of earth, space, and aeronautics information available on the Internet in educational formats. Several of our Internet sites have received a top score from one or more independent rating services. These sites include: Quest -- K-12 Internet Initiative and Passport to Knowledge. Through this program, collaborations are maintained with and support provided to 5,300 schools across the country. In FY 1998 LTP efforts will focus on distributing mature K-12 curriculum products featuring NASA science and engineering via the Internet. The products of eight cooperative agreements in K-14 aeronautics education will be delivered along with the instructional aids developed by staff at ten NASA field centers. In FY 1999 LTP will initiate a follow-on grant program funding the use of information technology in educational outreach efforts.

In FY 1997, the Educational Technology program began the development of a virtual education server, incorporating services such as Spacelink and the HPCC/LTP sites, as well as other education sites, in an effort to provide more user-friendly access to NASA

Education information; this effort will continue in FY 1998. The Educator Resource Center Network redesign effort to insure national access and to make greater use of emerging educational technologies. will be completed in FY 1998.

Educational Technology activities in FY 1997 included funding for the following activities directed by Congress in the Conference Report accompanying the FY 1997 VA-HUD-Independent Agencies Appropriation Act (P.L. 104-204): National Prototype Space Education Curriculum in conjunction with the Bishop Museum in Hawaii; further development of the American Museum of Natural History/National Center for Science, Literacy, Education and Technology: upgrades to Mobile Aeronautics Education Lab.; feasibility study to create a national residential high school at the Lewis Research Center: replication of the Science, Engineering, Mathematics, and Aeronautics Academy (SEMMA) program at Cuyahoga Community College: and increase learning effectiveness of the Classroom of the Future, by assessing and improving student scientific inquiry abilities using the Astronomy Village Program. In FY 1998, additional activities directed by Congress include the Alaska Learning Center, Apple Valley (CA) Learning Center, additional funding for the Bishop Museum (HI), California Discovery Science Center, K-12 Telecommunications, Louisiana Daily Living Center, and the Pennsylvania Education Telecommunication Center.

BASIS OF FY 1999 FUNDING REQUIREMENT

EVALUATION

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Evaluation	700	700	700

PROGRAM: GOALS

The goal of the evaluation program is: to provide documented evidence of the degree to which NASA's educational program, with its associated projects and activities, has accomplished its goals; and to develop a systematic strategy for collecting, aggregating, and reporting evaluation indicator data.

STRATEGY FOR ACHIEVING GOALS

NASA has undertaken a comprehensive effort to evaluate its education programs in order to demonstrate the accomplishment of achievable and measurable goals and objectives. Although every NASA education program currently has an evaluation component, a set of standard, agencywide indicators, metrics, and evaluation instruments is being developed for agencywide use. The data will be collected on-line in a single database capable of providing correlation and report generation capability. External education evaluation experts have also been engaged to provide guidelines and criteria for the analysis of qualitative and quantitative data to facilitate an in-depth survey of various programs offering recommendations and suggestions about the instruments in development.

MEASURES OF PERFC[illegible]E

NASA is currently developing and testing a coniprehensive system to evaluate its education programs in order to demonstrate the accomplishment of achievable and measurable goals and objectives. Based on recommendations provided by a study of the NASA Education Program by the National Research Council (NRC), NASA has established program goals, defined a comprehensive Education Framework which captures the elements of NASA's Education Program. This framework is detailed in NASA's *Strategic Plan for Education*, and supported by implementation plans developed by the Enterprises and NASA field installations between FY 1995 and the present. NASA utilizes an Internet-based system, for the collection, analysis, evaluation and reporting of standard and program unique data and program outcomes for all NASA education programs. This system, the NASA Education Evaluation System (EDCATS) has completed two field test years, each year capturing additional programs and data This system will provide summary data, follow-up, and participant feedback data in FY 1998.

ACCOMPLISHMENTS AND PLANS

NASA's Education Evaluation System (EDCATS), fully Operational in FY 1998, continues to add programs incrementally until all NASA education programs are included. As programs compile a firm set of baseline data, selected annual program targets will be established, as needed or required. Funding included in FY 1998 and FY 1999 will support the gradual expansion of the NASA Education Evaluation System data base to encompass all of NASA's Education programs. In FY 1997, all agency-wide programs were included in the EDCATS system; in FY 1998 center-unique programs will be integrated. By FY 2000 the system will be fully operational to track data and evaluation metrics for the entire NASA Education Program.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL, YEAR 1999 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS | **MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
Historically Black Colleges and Universities	31,300	30,000	28,000	SAT 6.2-8
University Research Center Awards	1,500	--	--	
Institutional Research Awards....................................	3,200	3,000	3,000	
Principal Investigator Awards	6,900	5,500	5,700	
Math and Science Education Awards	9,500	10,000	14,000	
Partnership Awards...	10,200	11,500	5,300	
Enterprise Program Funding *	[9,800]	[12,8001	[16,800]	
Other Minority Universities	23.500	21,400	17,900	SAT 6.2-20
University Research Center Awards	1,900	--	--	
Institutional Research Awards.....................................	2,400	2,400	3,000	
Principal Investigator Awards	5,600	3,000	4,000	
Math and Science Education Awards	9,100	8,500	6,600	
Partnership Awards...	4,500	7,500	4,300	
Enterprise Program Funding *	[3,5001	[8,000]	[12,0001	
Total Minority University Research Programs....................	54,800	51,400	45,900	
Total Enterprise Program Funding *..................................	[13,300]	[20,800]	[28,800]	
Total Program Funding to Minority University Research.....	68,100	72,200	74,700	

* Represents funding included in Enterprise budget request in support of Minority University Programs

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL *YEAR* 1999 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS **ITY UNIVER RESEARCH AND EDUCATION PROGRAM**

Distribution of Program Amount bv Installation	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Johnson Space Center	4,600	2,600	2,200
Kennedy Space Center	4,400	4,800	4,300
Marshall Space Flight Center	2,300	5,700	4,900
Stennis Space Center	2,500	3,000	2,600
Ames Research Center	5,000	2,200	1,900
Dryden Flight Research Center	1,800	2,700	2,300
Langley Research Center	3,800	5,000	4,300
Lewis Research Center	3,500	4,400	2,100
Goddard Space Flight Center	25,100	18,000	18,700
Jet Propulsion Laboratory	1,800	3,000	2,600
Total,,	54,800	51,400	45,900

PROGRAM GOALS

The Minority University Research and Education Programs (MUREP) focus primarily on expanding and advancing NASA's scientific and technological base through collaborative efforts with Historically Black Colleges and Universities (HBCU) and Other Minority Universities (OMU), including Hispanic-Serving Institutions (HSI) and Tribal Colleges and Universities (TCU). NASA's outreach to HBCU's and OMU's in FY 1999 will build upon the prior years' investments in HBCU and OMU research and academic infrastructure. Through infrastructure-building support, exposure to NASA's unique mission and facilities, and involvement in competitive peer review and merit selection processes, HBCU's and OMU's will be able to contribute significantly to the Agency's strategic goals and objectives. These contributions include the education of a more diverse resource pool of scientific and technical personnel who will be well prepared to confront the technological challenges to benefit NASA and the Nation. In addition to the federal mandates for HBCU's and OMU's, the strategic goals that guide NASA's MUREP are: (1) To foster research and development activities at HBCU's and OMU's which contribute substantially to NASA's niission; (2)To create systemic and sustainable change at HBCU's and OMU's through partnerships and progranis that enhance research and educational outcomes in NASA-related fields; *(3)* To prepare faculty and students at HBCU's and OMU's to successfully participate in the conventional, competitive research and education process; and (4)To increase the number of students served by HBCU's and OMU's to enter college and successfully pursue and complete degrees in NASA-related fields.

STRATEGY FOR ACHIEVING GOALS

NASA employs a comprehensive and complementary array of strategies to achieve these goals for both HBCU's and OMU's. These strategies include: (1) Working closely with NASA Strategic Enterprises, other government agencies, and interested parties to develop new research and education collaborations and partnerships to build infrastructure in NASA-related research areas; (2)Providing annual opportunities for HBCU's and OMU's to participate in competitive peer review and merit selection processes for research and education awards: *(3)*Encouraging and providing opportunities for faculty to conduct NASA research early in their careers: (4) Providing incentives for students to enter and remain in mathematics, science and technology disciplines; and (5)Developing and implementing evaluations to assess the effectiveness of the programs and to improve program delivery and results.

A strategy used to expand HBCU and OMU involvement in competitive peer review processes and to ensure the relevance of research conducted by HBCU's and OMU's is to involve NASA Strategic Enterprises early in the development of solicitation notices. Once Headquarters issues the notices, NASA Installations provide advice to prospective grantees, conduct peer reviews of proposals, and provide funding recommendations to the Office of Equal Opportunity Programs (OEOP) and the Strategic Enterprises. Once Headquarters makes selections, the research is returned to the nominating NASA Installation(s) or Jet Propulsion Laboratory (JPL) for grant award and technical management of the award. OEOP provides policy direction and additional funding. Oversight of the research performed at HBCU's and OMU's is conducted by the Strategic Enterprises in collaboration with OEOP.

The successful deployment of these strategies has resulted in the establishment of five different programmatic award categories which apply equally to the HBCU and OMU Programs, Selections for these awards are made mostly through the competitive peer review and merit selection processes. These awards include:

- University Research Center (URC) Awards
- Institutional Research Awards (IRA)
- Individual Principal Investigator's Research Awards
- Mathematics and Science Education Awards
- Partnership Awards

The NASA Strategic Enterprises and Program Offices provide funding and technical support to contribute to the success of the Minority University Research and Education Program (MUREP). The Institutional Research Awards (research) will be fully funded by Program Office funding in FY 1998 and FY 1999. In FY 1997, the Strategic Enterprises and Programs Offices provided $13.3 M in support of the URC and IRA s. In FY 1998, they have made available $20.8M to support competitively selected research awards at HBCU's and OMU's. In support of these awards, the FY 1999 budget request by the Enterprises and Program Offices includes an additional $8.0M, making the total $28.8M.

The Partnership Awards program was established in FY 1997 in response to Congressional direction included in the Conference Report accompanying the FY 1997 VA-HUD-Independent Agencies Appropriation Law (P.L. 104-204) specifying that additional funds be used for ".,.educationprograms which expand opportunities and enhance diversity in the NASA sponsored research and education community...". The initial set of 2-year Partnership Awards were made available to both HBCU's and OMU's in FY 1997. Additional funding was directed by Congress in the Conference Report accompanying the FY 1998 VA-HUD-Independent Agencies Appropriations Law (P.L. 105-65) to continue and expand the Partnership Award program. The additional funding of $9.0 million is being equally divided between the HBCU and OMU programs.

During FY 1999, NASA MUREP will continue to focus on its goals and strategies to integrate mission-focused research, technology transfer, and education at HBCU's and OMU's. Plans for new awards within designated award categories are dependent upon the number of expiring awards. Within this budget request, new opportunities are planned to replace expiring awards with new Individual Principal Investigator's Research Awards: Math, Science, and Education Awards: and Partnership Awards.

Efforts will continue to ensure that HBCU's and OMU's are knowledgeable of and responsive to the Agency's efforts to institute program performance reform, set specific program goals, measure program perfomlance against those goals, report publicly on their progress, and better respond to OEOP new fiscal requirements. These efforts should continue to enable HBCU's and OMU's to institute more effective planning, budgeting, program evaluation and fiscal accountability for NASA awards and funding. These collaborative efforts should enhance the effectiveness of NASA HBCU and OMU Programs, and improve Program outcomes, service quality, and customer satisfaction.

MEASURES OF PERFORMANCE

MUREP metrics are being continually improved. Performance data measuring program outcomes as well as participation is obtained through the required submission of annual performance reports and/or on-site or reverse-site reviews of each award. Each grant recipient submits an annual perfomiance report that is reviewed by a NASA Technical Monitor or a Technical Review Committee for qualitative and quantitative progress toward the project's and NASA program goals and objectives. Continuous assessment of this data has enabled OEOP MUREP to identify perforniance measures for research and education awards. As part of the grantee's annual reporting requirements, each awardee is now being required to respond to a set of uniform research or education outconies that enables OEOP to assess progress across all research or education awards. Additionally, as required by Executive Order 12876, at the end of each fiscal year, NASA measures its HBCU performance against the concluding fiscal year HBCU plan that was submitted to the White House Initiative Office and the Office of Management and Budget.

The uniform research and education outcomes were established in FY 1996 and expanded to all education awards in FY 1997. The objectives were to establish uniform outcomes for all NASA MUREP awards and to provide compact instruments for uniform collection of data keyed to those outcomes. This process reduces the collection of data to the minimal amounts possible, emphasizes outcomes and are applicable to any common set of awards. The data collected can be aggregated both horizontally and longitudinally, and permit adjustable benchmarking standards to be applied. The data are collected electronically over the World Wide Web. A single annual collection of data will be used to provide the information necessary for comparative and correlational analysis across research or education projects, and annual MUREP performance reports, including those required by the White House Initiative Offices on HBCU's, Educational Excellence for Hispanic Americans, and Tribal Colleges and Universities. The data are being used to provide input into NASA's Annual Performance Plan and in the budget formulation. Based on prior years' evaluation results, the following uniform measures of performance have been established for OEOP MUREP research and education awards.

RESEARCH MEASURES OF PERFORMANCE

- Participants
  - students, faculty, post-doctoral researchers, research associates supported.
- Student Outcomes
  - degrees awarded, post-graduation plans
- Research Outcomes
  - refereed papers, technical presentations. patents, commercial products, research funds leveraged from other sources.

EDUCATION AND TRAINING MEASURES OF PERFORMANCE

- Participants
  - students, teachers supported
- High School Student Outcomes
  - enrollment in Math, Science, Education and Technology (MSET) course, graduation, enrollment in college, and selection of MSET majors
- Bridge Student Outcomes
  - completed freshman year in college
- Undergraduate & Graduate Student Outcomes
  - degrees awarded, post-graduation plans
- Teacher Outcomes
  - received certificates

Continuous assessment of performance, through annual evaluations of individual awards and the collection of uniform outcomes across all research and education programs, will clearly indicate the impact of NASA MUREP on the scientific and technological base for NASA and the Nation, while minimizing the reporting burden on award recipients.

In FY 1997, funding reached 42 states and the District of Columbia, Puerto Rico and the Virgin Islands. The number of MUREP total awards made through NASA Installations and JPL was increased from $17M, or 37%. in FY 1996; to $38M, or 71% . The number of competitively peer-reviewed and merit selected MUREP awards was increased from 30 in FY 1996 to 85 in FY 1997. All MUREP requests for FY 1997 continuation funding were assessed for performance by the NASA Technical Officers; all awards funded for more than 2 years received on-site reviews,

In FY 1997, the institutional-based Undergraduate Researchers Program was reviewed and evaluated by external reviewers. The program performance was benchmarked against eight other similar federally-funded programs. Benchmarks were established arid in FY 1998 progress toward these benchmarks will be measured. Many grantees received national recognition. Five grantees (55% of the selectees) were selected for the FY 1997 Presidential Awards for Excellence in Science, Mathematics and Engineering Mentoring, and Florida A&M University was named the first College of the Year by Time Magazine.

At the end of FY 1997, NASA's investment in HBCU's and OMU's totaled $54.8M. Of this amount, 50 HBCU's were the direct recipients of 145 research and education awards valued at $31.3M; 57 OMU's received 175 awards valued at $23.5M. Included in the OMU awards and funding were 52 awards to 26 HSI's at $9.0M, 10 awards to 8 Tribal Colleges and Universities at $1.2M, 88 awards to other institutions of higher learning and 5 awards to non-universities such as the National Research Council.

For the FY 1997 reporting period (Academic Year 1996–97 and Summer 1997), MUREP solicited research projects, including 14 URC's, 5 research IRA's and 30 Faculty Awards for Research, reported the following outcomes. Research work was conducted by 388 professional-level investigators, including 277 faculty members, 80 research associates, and 31 postdoctoral fellows. A total of 863 students—511 undergraduates and 352 graduate students participated in these research activities. During the reporting period, these projects were able to leverage their NASA MUREP funding of $25.1 million (including $5.4 million for students) to an additional $35.3 million in research support, $9.3 million from other NASA programs, and $26.0 niillion from other agencies. Technology transfer activities reported included 21 patents disclosed, applied for, or awarded: and 14 commercial products being developed or marketed.

A major goal of MUREP is to increase the number of socially and economically disadvantaged and disabled students receiving advanced degrees and entering into careers in NASA-related fields. Of the 863 students involved in these research projects during the reporting period, 511 (59%) participated at the bachelor's-degree level, 259 (30%) participated at the master's-degree level, and 93 (11 percent) participated at the doctoral-degree level. During the reporting period, 275 students obtained degrees: 157 bachelor's degrees: 105 master's degrees: and 13 doctoral degrees. Also during the FY 1997 reporting period (Academic Year 1996–97 and Summer 1997), 218 MUREP education and training projects were conducted at HBCU and OMU institutions. During the reporting period, these projects in support of programs for students and teachers were able to leverage their NASA MUREP funding of *$3*1 million to an additional $5 million in support from industry, other government agencies and non-profit organizations.

During FY 1998, NASA MUREP will continue to focus on its goals and strategies to integrate mission-focused research, technology transfer, and education at HBCU's and OMU's. NASA will continue and expand partnership awards that leverage NASA's investment by encouraging collaboration among NASA, university researchers and educators, and the aerospace industry. Plans for new awards within the other designated award categories are dependent upon the number of expiring awards. It is forecasted that opportunities will be provided for new IRA's, Individual Principal Investigator's Research awards and Math, Science, and

Education awards. The financial investment of $20.8M by **NASA** Strategic Enterprises arid Program Offices is planned for FY 1998. **A** portion of this funding will be used to initiate the next group, Group ***3,*** of University Research Centers.

In FY 1999. as in FY 1998, **NASA** MUREP will continue to focus on its goals and strategies to integrate mission-focused research, technology transfer, and education at HBCU's and OMU's. **NASA** will emphasize partnership awards that leverage **NASA's** total research investment in higher education institutions and aerospace industry. **NASA** will continue to increase the number of solicited awards that are selected through the peer review award process. Plans for new awards categories are dependent upon the number of expiring awards. It is forecasted that expiring awards will provide opportunities for new Institutional Research Centers, Individual Principal Investigator's Research awards, and Math, Science, and Education awards. In FY 1999, the Strategic Enterprises and Program Offices investment will increase to $28.8M and technical involvement by **NASA** Strategic Enterprises and Program Offices in research conducted by HBCU's and OMU's will continue.

BASIS OF FY 1999 FUNDING REQUIREMENT

HISTORICALLY BLACK COLLEGES AND UNIVERSITIES

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
University Research Centers	1,500		
Institutional Research Awards	3,200	3,000	3,000
Principal Investigator Awards	6,900	5,500	5,700
Math Science and Education Awards	9,500	10,000	14,000
Partnership Awards	10,200	11,500	5,300
Total Minority Programs	31,300	30,000	28,000
Enterprise Program Funding*	9,800	12,800	16,800
Total, Historically Black Colleges and Universities	41,100	42,800	44,800

* Represents funding included in Enterprise budget request in support of Minority University Programs

PROGRAM GOAL

NASA's HBCU program is the Agency's direct response to Executive Orders 12876, and 12928, which require all federal Agencies to strengthen the capacity of HBCU's to provide quality education, and to participate in and benefit from federal programs. This program aims to expand the research capabilities of selected HBCU's with emphasis on building research infrastructure, and on exposure to the NASA peer review process. This will to increase opportunities for HBCU faculty and students to participate in and benefit from NASA's research and education progranis.

STRATEGY FOR ACHIEVING GOALS

HBCU's were involved in NASA's mission before man set foot on the Moon in 1969. In 1980, President Jimmy Carter signed Executive Order 12232 which established a federal program "...tostrengthen and expand the capacity of HBCU's to provide quality education." Executive Orders issued by Presidents Ronald Reagan and George Bush strengthened this program. NASA's current initiatives for HBCU's are based upon two recent Executive Orders. Executive Order 12876, signed November 1, 1993, by President William J. Clinton, mandates that agencies "..advancethe development of human potential, to strengthen the capacity of HBCU's to participate in and benefit from federal programs to achieve an increase in the participation by HBCU's in federal programs." Executive Order 12928, signed February 16, 1994, by President Clinton directs federal agencies to promote procurement with

“.,.HistoricallyBlack Colleges and Minority Institutions.” NASA employs a comprehensive strategy to accomplish the HBCU program goals. This approach is carried out through awards in five areas:

1. University Research Centers Awards
2. Institutional Research Awards
3. Individual Principal Investigator Awards
4. Mathematics and Science Awards
5. Partnership Awards

The NASA **HBCU University Research Centers (URC) Awards** began in FY 1991 with 5-year awards that established seven HBCU Research Centers (Group 1) by the Headquarters Office of Space Science and Applications: the Office of Aeronautics; the Office of Space Flight; and the Office of Equal Opportunity Programs, The program goals are to achieve a broad-based, competitive aerospace research capability among the Nation’s HBCU’s that will: foster new aerospace science and technology concepts: expand the Nation’s base for aerospace research and development; develop mechanisms for increased participation by faculty and students of HBCU’s in mainstream research; and increase the productivity of students, who are U. S. citizens and who have historically been underrepresented, with advanced degrees in NASA-related fields. Four additional HBCU Research Centers were added as a result of a second competition in FY 1996 (Group 2). Funding for the HBCU research centers was primarily provided by the Strategic Enterprises in FY 1997 and will be totally provided in FY 1998 and FY 1999.

GROUP 1 HBCU Research Centers:

Universitv	Research Focus	Lead NASA Installation
Clark Atlanta University	High Performance Polymers and Composites Research Center	Lewis Research Center
Fisk University	Center for Photonic Materials and Devices	Marshall Space Flight Center
Florida A&M University	Center for Nonlinear and Nonequilibrium Aeroscience	Langley Research Center
Hampton University	Center for Optical Physics	Langley Research Center
Howard University	Center for the Study of Terrestrial and Extraterrestrial Atmospheres	Goddard Space Flight Center
North Carolina A&T State University	Center for Aerospace Research	Langley Research Center
Tuskegee University	Center for Food and Environmental Systems for Human Exploration of Space	Johnson Space Center

GROUP 2 HBCU Research Centers:

University	Research Focus	Lead NASA Installation
Alabama A&M University	Center for Hydrology, Soil Climatology and Remote Sensing	Marshall Space Flight Center
Morehouse School of Medicine	Space Medicine and Life Sciences Research Center	Johnson Space Center
Prairie View A&M University	Center for Applied Radiation Research	Johnson Space Center
Tennessee State University	Center for Automated Space Science	Goddard Space Flight Center

In order to foster closer ties between the HBCU Research Centers and NASA, a Lead NASA Installation was designated for each URC. Beginning with the FY 1997 renewals, the Lead Installations became responsible for directly managing the cooperative agreements for the URC's, and for increasing the HBCU involvement in ongoing NASA research and development activities. Collaborations with other NASA Installations, industry, and other universities are continuing to be strongly encouraged. OEOP continues to maintain responsibility for program policy and oversight.

The HBCU Research Centers, along with the Other Minority Universities (OMU) research centers, have formed a National Alliance of NASA University Research Centers (NANURC). This Alliance has established an annual National Conference of the University Research Centers, created pathways for developing greater collaborations between the URC's, and is exploring avenues for increasing the number of advanced degrees being awarded to disadvantaged students. NASA is strongly supportive of this concept and is actively working with the Alliance to further develop and strengthen their organization.

The goal of the **HBCU Institutional Research Awards (IRA)** is to improve academic, scientific and technology infrastnicture and broaden the NASA-related science and technology base at HBCU's. Two awards with different focus areas have been made under this category. The first IRA (Research) was made in FY 1994 and was limited to only OMU's. The second IRA (Network Resources and Training Sites (NRTS)) were open to both HBCU's and OMU's. The IRA (NRTS) is designed to improve the in-house capability of HBCU's to electronically access science data and computational resources: to develop mechanisms to support, sustain and evolve the network infrastructure of the targeted universities and colleges: and to make HBCU's more effective in the competitive process for NASA and other science, engineering and technology funding opportunities. IRAs provide for the acquisition of research equipment and equipment essential to Internet connectivity.

The strategies for achieving the IRA (NRTS) goals include: (1) establishing five HBCU's as lead NRTS; and (2) holding the lead HBCU accountable for providing Internet connectivity to other HBCU's and/or OMU's and public schools, and for training students, faculty and teachers to build computers, maintain and effectively utilize the Internet to compliment teaching and research collaborations and delivery. The lead NASA Installation, Goddard Space Flight Center (GSFC), manages the IRA (NRTS) under the auspices of GSFC's Minority University - Space Interdisciplinary Network (MU-SPIN) Program. The Offices of Equal Opportunity Programs, Space Science, and Earth Science collaboratively provide funding and oversight for the GSFC MU-SPIN Program.

NASA Headquarters Program Offices, Field Installations, and JPL support IRA programs through direct funding, use of their facilities. and commitment of their personnel to serve on Technical Review Committees (TRC) and assist in other facets of program implementation. Students and principal investigators involved in IRA (NRTS) spend time on-site at the Installations and JPL throughout the year.

The goal of the **HBCU Principal Investigator (PI) Awards** for research is to provide faculty at HBCU's with an opportunity early in their careers, to integrate the research and education components with the unique mission requirements of a specific NASA Installation or JPL. By involving HBCU faculty and students, the Agency hopes to increase the interest of traditionally underrepresented communities in the Agency's mission and enhance a broader array of America's citizenry in the NASA-sponsored research community.

The primary strategy for implementing the PI Awards for research is through a competitive peer review and merit selection process in collaboration with the Strategic Enterprises, NASA Installations and JPL. Other strategies include: (1) Have discipline-related personnel at Headquarters and the NASA Installations and JPL be responsible for serving as points-of-contact for faculty interested in pursuing an award in this category; (2) Place responsibility for conducting the technical evaluations and making recommendations to Headquarters for funding consideration on the interested NASA Installation or JPL; ***(3)*** Provide funding to the nominating NASA Installation or JPL to make PI Awards for research: and (4) Hold the NASA Installation or JPL responsible for managing the awards.

Within this category, each fiscal year, HBCU's are invited to submit proposals for the Faculty Awards for Research (FAR). Funding for this program provides for competitive peer review selection of outstanding and promising engineering, physical and life science-tenured and tenure-track faculty at minority institutions early in their academic careers who are capable of contributing to the Agency's research objectives and who have limited past NASA research grant experience. This award provides faculty members with sufficient research support and exposure to the NASA peer review process lo enable them to demonstrate creativity, productivity, arid future promise in the transition toward achieving competitive awards in the Agency's mainstream research processes.

The **HBCU Math and Science Education Awards** build upon these institutions' outstanding ability to provide excellence in mathematics, science, engineering and technology (MSET) training while increasing the participation and achievement of socially and economically disadvantaged and disabled students in MSET fields at all levels of education. Awards are made in the following three areas: undergraduate and graduate, teacher preparation and enhancement, and precollege activities.

MSET Awards contribute to the national education goals by integrating the contents from the NASA mission into the educational outreach projects at HBCU's that increase the number and strengthen the skills, knowledge, and interest of students and teachers in MSET-based academic programs. MSET awards consist of both unsolicited and solicited awards. The solicited awards are the NASA Precollege Awards for Excellence in Mathematics, Science, Engineering and Technology (PACE/MSET) program and the Mathematics, Science, and Technology Awards for Teacher and Curriculum Enhancement Program (MASTAP). These awards will accomplish the following:

Undergraduate and Graduate Awards

Graduate students are provided scholarships, fellowships, internships, research opportunities in NASA-related fields, and other supportive services. **In** addition to the above, undergraduate students are provided access to tutors, mentors, and more group activities through the undergraduate awards.

The undergraduate projects identify high school seniors and continuing first-year college students majoring in science, engineering, mathematics or computer science and provides student incentives through OMU's with proven records of recruiting, retaining, and graduating disadvantaged students in these fields. The students receive tuition support: are monitored, tutored and nurtured; and spend their summers conducting research with principal investigators at their universities, NASA Installations, federal laboratories or private industry. The NASA Installations and the JPL provide hands-on research experiences arid mentors for those students. NASA requires active participation from the institutions, which provide student support services, faculty mentors, research experiences, additional tuition support as needed, arid administrative support. It is expected that these students **will** form part of the pool from which NASA selects graduate researchers.

Teacher Preparation and Enhancement Awards

Under the Mathematics, Science, and Technology Awards for Teacher and Curriculum Enhancement Program (MASTAP), teacher and curriculum enhancement programs are designed to expand the number of teachers and strengthen their MSET skills to better enable them to integrate content from NASA's mission into middle and high schools' curriculum for presentation in schools with substantial enrollments of disadvantaged students.

Precollege Awards

This program provides students with the necessary academic preparation and motivation to successfully complete challenging college preparatory MSET courses, aims to heighten students' interest and awareness of career opportunities in MSET fields, and to expose students to the NASA mission, research, and advanced technology through role models, mentors, and participation in research and other educational activities.

In FY 1997, consistent with Congressional direction and funding, NASA initiated the **Partnership Awards** program to "expand opportunities and enhance diversity in the NASA sponsored research and education community...achieve a balance between the proportion of NASA funding received by minority institutions of higher education and other institutions of higher education." One of the goals of the Partnership Awards is to strengthen NASA Installations' and JPL's partnerships with HBCU's through projects which are unique and innovative, which fall outside of the usual MUREP competitive programs, and which have high potential for long-term support from other sources.

The NASA Installations and JPL are invited to jointly submit, with Presidents of Minority Universities, concept papers to Headquarters for competitive review and selection in three different categories: research: education: or combination research and education. Selected concept papers are expected to culminate in an award to a HBCU. All concept papers must be responsive to the Agency's strategic direction; the federal mandates related to HBCU's and the NASA MUREP goals.

Additional funding was directed in the Conference Report accompanying the FY 1998 VA-HUD-Independent Agencies Appropriation Law (P.L. 105-65) to continue and expand the Partnership Award program. The $9.0M additional funding is to be equally divided between the HBCU and OMU programs. At least two new Partnership Awards will be made in FY 1998 and continued funding will be provided in FY 1999. The goal of the Partnership Awards program is to achieve the following outcomes: 1) more competitive undergraduate U. S. students with research training, who are exposed to NASA cutting-edge technology, and who are better prepared to enter MSET graduate programs or MSET careers; 2) enhanced undergraduate courses and curriculum, including laboratory-based curricula that foster collaboration between NASA-funded research and education faculty; and 3) produce model HBCU that integrate NASA-related research into appropriate areas of the undergraduate curriculum.

NASA has established Technical Review Committees (TRC's)to provide technical guidance and on-site reviews to recipients of IRA's and Research Center awards. NASA promotes collaboration between its HBCU-funded programs, the NASA Installations and JPL; and with entities outside of NASA. Institutions are encouraged to seek funding through NASA's traditional opportunities. as well as other government agencies and private sources. This is done in an effort to promote future sustainability. Research Centers, IRA's and PI Awards require substantial undergraduate and graduate student involvement in research projects. The mathematics and science awards are normally managed by personnel at the NASA Installations and JPL.

NASA Headquarters Program Offices, Field Installations, and JPL support the HBCU program through direct funding, use of their facilities, and commitment of their personnel to serve on TRC's and assist in other facets of program implementation. Numerous students and PI's from HBCU's spend time on-site at the Installations and JPL throughout the year.

MEASURES OF PERFORMANCE

As required by Executive Order 12876, NASA conducts an annual assessment toward its HBCU goals. The results of this agencywide assessment is reported to the White House lnitiative Office on HBCU's and the Office of Management and Budget. The measures of performance include the number of awards and funding to HBCU's in the following categories: research and development; program evaluation; training; facilities and equipment; fellowships, internships, traineeships, recruitment and IPA's; student tuition assistance, scholarships, and other aid; direct institutional subsidies; third-party awards: private-sector involvement; and administrative infrastructure. NASA's FY 1997 performance in these areas is required to be reported in April 1998. In preparation for this report, progress has been measured through the annual assessment of individual awards and through the collection of uniform outcomes data.

Additional metrics for the IRA (NRTS) will be designed to capture the technology and education focus of these awards. Specific metrics will include:

1) the number of HBCU's and public schools connected to the Internet

2) the number of faculty, teachers and students trained to utilize the Internet to enhance research and educational outcomes

ACCOMPLISHMENTS AND PLANS

For the FY 1997 reporting period (Academic Year 1996–97 and Summer 1997), research projects funded through MUREP solicitations at HBCU's, including 11 URC's and 20 FAR's, reported the following outconies. Research work was conducted by 240 professional-level investigators, including 173 faculty members, 53 research associates, and 14 postdoctoral fellows. A total of 507 students-299 undergraduates and 208 graduates-participated in these research activities. The research accomplishments were documented in 219 refereed papers or book chapters published during this time period. Significantly, 75 students were authors or co-authors of these publications. *An* additional 97 papers or book chapters, including 51 student authors or co-authors, were accepted for publication during this period. The broader research community was informed of this work through 442 technical presentations, including 103 presentations given by students.

During the reporting period, these projects were able to leverage their **NASA** MUREP funding of $15.6 million (including $3.2 million for students) with an additional $21.1 million in research support, $6.2 million from other NASA programs, and $14.9 niillion from other agencies. Technology transfer activities reported included 9 patents disclosed, applied for, or awarded; and 8 commercial products being developed or marketed.

A major goal of HBCU research programs is to increase the number of disadvantaged students receiving advanced degrees and entering into careers in NASA-related fields. Of the 507 students involved in these research projects during the reporting period, 299 (59%) participated at the bachelor's-degree level, 161 (32%) participated at the master's-degree level, and 47 (9%) participated at the doctoral-degree level. During the reporting period, 159 students obtained degrees; 93 bachelor's degrees; 63 master's degrees: and 3 doctoral degrees.

During the FY 1997 reporting period (Academic Year 1996–97 and Summer 1997), 66 MUREP education and training projects were conducted at HBCU institutions. The programs included precollege and bridge programs, education partnerships with other universities, industry and nonprofit organizations, NRTS, teacher training, and graduate fellows and/or undergraduate programs. These progranis reached a total of 24,685 participants, with the predominant number at the precollege level. The programs achieved major goals of heightening students' interest and awareness of career opportunities in MSET fields, and exposing students to the NASA mission, research and advanced technology through role models, mentors. and participation in research and other educational activities. The reported outcomes on the survey were as follows. Grantees reported 4,088 high school students in NASA programs and 3,164 high school students selected college preparatory MSET courses, 764 high school graduates, 917 enrolled in college, and 282 selected MSET majors. There were 836 high school graduates (bridge students) in NASA programs and 126 students who successfully completed their freshman year. There were 756 teachers in teacher programs and 59 teachers received certificates. For undergraduate student programs of 87 students, 15 received degrees, 11 are continuing for the next degree, 2 are employed in a NASA-related field, 12 gave presentations at **NASA** Installations, and 1 student presented at a national/international conference. There were 22 graduate students reported in the survey, 10 received Masters degrees, 5 continuing for the next degree, and 2 employed in a NASA-related field. Thirteen students gave presentations at NASA Installations.

University Research Centers (URCs)

The special review teams assembled in FY 1996 to evaluate the first group of HBCU Research Centers returned reviews which exceeded expectations. As a result, in FY 1997, all seven of the Group 1 awardees were extended for a second 5 year period based on performance. For the first 5 years, each HBCU research center received up to $2M per year. These funds were considered necessary to establish a research infrastructure capable of sustaining long-term success in their research and education efforts. For the second 5 years, the funding will be reduced to a maximum of $1M per year per Research Center. This reduced funding level recognizes and encourages the movement of the HBCU Research Centers towards self-sufficiency through other funding sources.

The second group of HBCU Research Centers entered their third year of funding during FY 1997. This group is funded at a maximum of $1.5M per year per Research Center for their first 3 years (including FY 1997). In FY 1998 and FY 1999, funding will drop lo a maximum $1.0M per year per Research Center.

For the FY 1997 reporting period (Academic Year 1996–97 and Summer 1997), the 11 HBCU Research Centers in the URC program reported the following outcomes. Research work was conducted by 205 professional-level investigators, including 150 faculty members, 41 research associates, and 14 postdoctoral fellows. A total of 393 students-227 undergraduates and 166 graduates-participated in these research activities. The research accomplishments were documented in 208 refereed papers or book chapters published during this time period. Significantly, 70 students were authors or co-authors of these publications. An additional 88 papers or book chapters, including 41 student authors or co-authors, were accepted for publication during this period. The broader research community was informed of this work through 390 technical presentations, including 89 presentations given by students.

During the reporting period, these projects were able to leverage their NASA MUREP funding of $14.2 million (including $2.7 million for students) with an additional $19.0 million in research support, $5.8 million from other NASA programs, and $13.2 niillion from other agencies. Technology transfer activities reported included 9 patents disclosed, applied for, or awarded; and 8 commercial products being developed or marketed.

A major goal of the HBCU Research Centers is to increase the number of disadvantaged students receiving advanced degrees and entering into careers in NASA-related fields. Of the 393 students involved in these research projects during the reporting period, 227 (58%) participated at the bachelor's-degree level, 121 (31%) participated at the master's-degree level, and 45 (11%) participated at the doctoral-degree level. During the reporting period, 127 students obtained degrees: 68 bachelor's degrees; 56 master's degrees; and 3 doctoral degrees.

In FY 1998, funding from the Strategic Enterprise and Program offices will continue to fully support 11 URC's, to develop broad-based competitive research capability in areas related to the four strategic enterprises, while expanding the Nation's base for aerospace research and development, technology transfer, increasing the participation of HBCU faculty and students in the Agency's research, and contributing to the national production of Americans with Ph.D. degrees in NASA-related disciplines. Two new research centers will be selected through a competitive process and the peer review process will begin for consideration of a second 5-year award for the second group.

In FY 1999, 13 URC's will continue to be funded by the strategic enterprise and program offices to continue the development of broad-based competitive research capability in areas related to the four strategic enterprises while expanding the Nation's base for aerospace research and development, technology transfer, increasing the participation of HBCU faculty and students in the Agency's research, and contributing to the national production of Americans with Ph.D. degrees in NASA-related disciplines.

Institutional Research Awards (Network Resources And Training Sites (NRTS))

Five HBCU's received renewal awards in FY 1997 for IRA (NRTS). These NRTS are a part of a network that encompasses seven regions that cover the 50 states, Puerto Rico and the Virgin Islands. A minimum of two faculty/teacher/student regional training workshops per institution were held this year.

University	Research Focus	Lead NASA Installation
Prairie View A&M University	Regional NRTS	Goddard Space Flight Center
Elizabeth City State University (ECSU)	Regional NRTS at ECSU	Goddard Space Flight Center
Morgan State University (MSU)	NRTS at MSU	Goddard Space Flight Center
South Carolina State University	NRTS	Goddard Space Flight Center
Tennessee State University (TSU)	NASA/TSU NRTS	Goddard Space Flight Center

In FY 1997, IRA (NRTS) connected 162 HBCU's and K- 12 public schools to the Internet. Approximately 4,700 faculty, 3,500 administrative staff, and 83,000 students were trained to utilize the Internet.

In FY 1998, funding will continue for five IRA (NRTS) selected to bring advanced computer networking infrastructure and technologies to other institutions of higher education and schools with substantial enrollnients of socially and economically disadvantaged and disabled students in their regions. These institutions are responsible for information dissemination sites, developing faculty and student network skills, and user working groups. These funds will support the fourth year of a 5-year award. One new IRA will be selected in collaboration with the Office of Space Science University-Class Explorer (UNEX) niission. This collaboration will foster HBCU participation in NASA space science missions. The Office of Equal Opportunity Programs and the Office of Space Science have cooperated to build incentives for including HBCU/OMU investigators in proposal teams for the UNEX Announcement of Opportunity to be released early in FY 1998. The selection criteria favor teams with substantial HBCU participation, and OEOP will provide up to $250,000 per selected project in capital investment funding (human resources, facilities, equipment, etc.) to further enhance the infrastructure of participating HBCU's. One UNEX mission will be selected in FY 1998.

In FY 1999, funding will continue for five IRA (NRTS) selected to bring advanced computer networking infrastructure and technologies to other institutions of higher education and schools with substantial enrollments of disadvantaged students in their regions. These funds will support the fifth-year of a 5-year award. In addition to the new IRA's selected in FY 1998 in collaboration with the Office of Space Science UNEX mission, one new IRA will be selected for this collaborative program.

Principal Investigator Awards For Research

The PI Awards for Research are composed of unsolicited awards and awards made based on solicitations to faculty members.

In FY 1997, there were nine FAR-funded third-year awards, 15 second-year awards, 14 new awards and expanded grants to include support for research equipment and for graduate and undergraduate students. For the FY 1997 reporting period (Academic Year 1996–97 and Summer 1997), 20 FAR projects at HBCU's reported the following outcomes. Research work was conducted by 35 professional-level investigators, including 23 faculty members and 12 research associates. A total of 114 students-72 undergraduates and 42 graduates - participated in these research activities. The research accomplishments were documented in 11 refereed papers or book chapters published during this time period. Significantly, 5 students were authors or co-authors of these publications. An additional 9 papers or book chapters, including 10 student authors or co-authors, were accepted for publication during this period. The broader research community was informed of this work through 52 technical presentations, including 14 presentations given by students.

During the reporting period, these projects were able to leverage their NASA MUREP funding of $1.4 million (including $0.5 million for students) with an additional $2.1 million in research support, $0.3 million from other NASA programs, and $1.8 million from other agencies.

A major goal of the FAR program is to increase the number of socially and economically disadvantaged and disabled students receiving advanced degrees and entering into careers in NASA-related fields. Of the 114 students involved in these research projects during the reporting period, 72 (63%) participated at the bachelor's-degree level, 40 (35%) participated at the master's-degree level, and 2 (2%) participated at the doctoral-degree level. During the reporting period, 32 students obtained degrees: 25 bachelor's degrees and 7 master's degrees. Of these graduates, 97% were members of groups historically underrepresented in NASA-related fields.

FY 1998 funding will support 15 third-year, 14 second-year and 26 new FAR awards. FAR grants provide for research and student support and exposure to the NASA peer review process to enable them to demonstrate creativity, productivity, and future promise in the transition toward achieving competitive awards in the Agency's mainstream research activities. The number of unsolicited awards will be decreased to accommodate the reduction in funding from FY 1997 to FY 1998.

FY 1999 funding will support 14 third-year, 26 second-year and 17 new awards and continue NASA Installation PI awards. The number of unsolicited awards will continue to be decreased.

Efforts will continue to have the majority of HBCU research selected for funding to be made through competitive peer review and merit selection processes. Through more involvement in processes similar to FAR, it is expected that opportunities for participation in the Agency's mainstream research will expand as recipients' research capabilities are enhanced through interaction with NASA researchers and faculty. Additionally, the pool of socially and economically disadvantaged students with research experience and interest in pursuing advanced MSET degrees in the fields of science, engineering, and mathematics will increase through faculty support.

Math And Science Education Awards

The Math and Science Education Awards are composed of unsolicited awards and awards made based on solicitations. Primary funding support the following four focus areas: undergraduate awards; graduate awards; precollege awards: and teacher enhancement and preparation awards.

The primary award for the teacher enhancement and preparation awards is the Mathematics, Science, and Technology Awards for Teacher and Curriculum Enhancement Program (MASTAP), designed to expand the number of teachers and strengthen their MSET skills to better prepare them to teach in middle and high schools that have substantial enrollments of disadvantaged students.

In FY 1997, NASA supported four MASTAP continuation awards at HBCU's for $200,000 each. These programs are in the second year of a 3-year award. MASTAP produced numerous instructional models, curriculum, publications, presentations at professional conferences, certified teachers and a resource center. Several teachers completed Masters Degrees. Pre-service teachers have gained valuable classroom experience while at the same time providing extra attention to students in socially and economically disadvantaged classrooms. These programs have had a positive impact on both the universities which implement them and on the school districts with which they have partnered. The program is currently being reviewed with a goal to widely distribute effective instructional materials, curriculums and models developed by MASTAP programs.

In FY 1998, funding will continue for the four previously awarded grants and lessons learned from these MASTAP grants will be utilized in developing a new MASTAP solicitation to fund up to six new awards. Measures and metrics will be revised and utilized in program evaluation. A network of institutions and PI's who have implemented MASTAP programs will be established. Innovative instructional materials, curriculums and models developed by MASTAP programs will be distributed to a wide audience and a network of MASTAP institutions, PI's and past participants will be established.

FY 1999, funding will provide for up to six second-year and six new MASTAP awards. Innovative approaches will be utilized *to* distribute effective instructional materials, curriculums and models developed by MASTAP programs. Efforts will continue to maintain and augment a network of MASTAP institutions, Principal Investigators and past participants.

In FY 1997, funding supported continuation of nine HBCU Precollege Awards for Excellence in Mathematics, Science, Engineering and Technology (PACE/MSET). In FY 1998, PACE funding will support four third-year, two second year, and eight new HBCU PACE/MSET awards. Through these PACE awards, a large number of socially and economically disadvantaged precollege students are reached and challenged to excel in MSET-based college preparatory courses. In FY 1999, PACE funding will support two third-year, eight second year, and replace expiring awards with four new HBCU PACE awards.

Partnership Awards

In response to Congressional direction included in the Conference Report accompanying the FY 1997 VA-HUD-Independent Agencies Appropriations Act (P.L. 104-204), NASA established the Partnership Award program. In FY 1997. more than 200 concept papers were received by the Agency in response to the solicitation, from which receive 44 2-year Partnership awards were selected. The institutions were from 14 states and the District of Columbia.

In FY 1998, the FY 1997 awards will continue to be incrementally funded. Two new awards will be made to facilitate the integration of NASA-sponsored research by strengthening the collaboration among NASA-funded researchers and educators, thereby enhancing mathematics, science, and technology educational outcomes.

In FY 1999, funding will provide second-year funds for two PACE awards and to fund 10 new awards will replace expiring grants.

BASIS OF FY 1999 FUNDING REQUIREMENT

OTHER MINORITY UNIVERSITIES

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
University Research Centers	1,800		
Institutional Research Awards	4,800	2,400	3,000
Principal Investigator Awards	5,600	3,000	4,000
Math Science and Education Awards	6,800	8,500	6,600
Partnership Awards	4,500	7,500	4.300
Total Minority Programs	23,500	21,400	17,900
Enterprise Program Funding *	3,500	8,000	12,000
Total, Other Minority Universities	27,000	29,400	29,900

* Represents funding included in Enterprise budget request in support of Minority University Programs

PROGRAM GOAL

The primary goal of NASA's OMU program is to increase the opportunities for Hispanic-Serving Institutions (HSI's), Tribal Colleges and Universities (TCU) and educational organizations serving substantial numbers of people with disabilities to participate in and benefit from NASA's research and education programs.

STRATEGY FOR ACHIEVING GOALS

In the House and Senate Reports accompanying the FY 1985 VA-HUD-Independent Agencies Appropriations Act (P. L. 98-371), Congress established building relationships between NASA and minority institutions of higher education as a priority. Language included in both reports (House Report 98-803 and Senate Report 98-506) directed NASA to "...review institutioris of higher learning having significant minority enrollments to find ways to build closer relations with such schools, meet NASA's research objectives and increase the number of individuals from underrepresented groups in the pool of graduate researchers...build a closer relationship with institutions serving significant numbers of minorities..." In response to this Congressional mandate, NASA established the OMU Program in 1991. Since that time, Executive Orders and congressional reports have provided additional guidance to the Agency to strengthen its research and education programs with OMU's. In 1994, Executive Order 12900 (February 22, 1994) mandated that agencies increase Hispanic American participation in federal education programs where Hispanic Americans currently are underserved, and Executive Order 12928 (September 16, 1994) directed federal agencies to promote procurement with "...Historically Black Colleges and Minority Institutions." Congress directed funding increases for the HSI's. Additionally, congressional direction was provided to NASA in the Conference Report accompanying the **FY** 1995 VA-HUD-Independent Agencies Appropriations Act (P.L. 103-327) to establish NASA Research Centers at the HSl's.

NASA responded to the early congressional and Executive Branch direction by formulating a 5-year plan for the OMU program in **FY** 1991 to strengthen the Agency's research initiatives at OMU's. This plan consists of three phases: (1) individual principal investigator research awards; (2) institutional research awards: and (3) teacher training and student programs focusing on NASA-related disciplines. The plan addressed all institutions with significant minority populations other than HBCU's. The OMU plan was expanded in **FY** 1993, when the **NASA** Administrator signed a plan to strengthen the Agency's relationships with HSI's. The direction received from Congress and the Executive Branch is reflected in the current program plan for OMU's.

President Clinton signed Executive Order 13021 "Tribal Colleges and Universities," on October 19, 1996, which directed federal agencies and departments to strengthen their relationships with Tribal Colleges and Universities. In response to the Tribal Colleges Executive Order, NASA is developing a 5-year plan of action and will submit annual accomplishment reports when the White House Initiative Office for Tribal Colleges is established. Present awards to TCU's are encouraged within the five programmatic awards.

NASA strategies for achieving the goals of the OMU Program reflect those established in the HBCU Program. However, because of the differences in the evolution of minority institutions and the particularities of federal mandates for HBCU's and Hispanic Americans, NASA's approach and implementation plan has been adjusted to take these factors into consideration. **For** example, the federal mandate for Hispanic Americans directs federal agencies to "....improve educational outcomes for Hispanic Americans participating in federal education programs...". As a result, the Agency has placed greater emphasis on mathematics and science awards than on institutional research awards. NASA employs a comprehensive strategy to accomplish the HBCU program goals. This approach is carried out through awards in five areas:

1. University Research Centers Awards
2. Institutional Research Awards
3. Individual Principal Investigator Awards
4. Mathematics and Science Awards
5. Partnership Awards

The NASA **OMU University Research Centers Awards program** began in **FY** 1995 with the establishment of three OMU Research Centers designed to achieve a broad-based. competitive aerospace research capability among the Nation's OMU's. The goals of the OMU Research Centers Awards programs are to: foster new aerospace science and technology concepts; expand the Nation's base for aerospace research and development; develop mechanisms for increased participation by faculty and students of OMU's in mainstream research; and, increase the production of students who are U. S. citizens and have historically been underrepresented, with advanced degrees in NASA-related fields.

Funding for the OMU research centers is primarily provided by the Strategic Enterprises in **FY** 1997 and will be totally funded by the Strategic Enterprises in **FY** 1998 and **FY** 1999.

OMU Research Centers:

University	Research Focus	Lead NASA Installation
University of New Mexico	Center for Autonomous Control Engineering	Anies Research Center
University of Texas at El Paso	Pan American Center for Earth and Environniental Studies	Goddard Space Flight Center
University of Puerto Rico at Mayaguez	Tropical Center for Earth and Space Studies	Goddard Space Flight Center

In order to foster closer ties between the OMU research centers and NASA, a Lead NASA Installation has been designated for each URC. Beginning with the FY 1997 renewals, the Lead Installations have become responsible for directly managing the URC cooperative agreements, and for increasing HBCU involvement in ongoing NASA research and development activities. Collaborations with other NASA Installations, industry, and other universities will continue to be strongly encouraged.

The OMU Research Centers, along with the HBCU research centers, have formed a National Alliance of NASA University Research Centers (NANURC). This Alliance has established an annual National Conference of the University Research Centers, created pathways for developing greater collaborations between the University Research Centers, and is exploring avenues for increasing the number of advanced degrees being awarded to disadvantaged students. NASA is strongly supportive of this concept and is actively working with the Alliance to further develop and strengthen their organization.

The goal of the **OMU Institutional Research Awards** (IRA) is to improve academic, scientific and technology infrastructure and broaden the NASA-related science and technology base at OMU's. Two awards with different focus areas have been made under this category. The first IRA (Research) was made in FY 1994 and was limited to only OMU's. The second IRA (Network Resources and Training Sites [NRTS]) were open to both OMU's and HBCU's. The objectives of the IRA (Research) are: to strengthen and improve core research areas of significance to the NASA mission: to increase the number of students who are U. S. citizens conducting space research and working in NASA-related disciplines: and lo strengthen the research environment of eligible institutions and the capability of individuals by supporting the institutional infrastructure (through the acquisition of research equipment), faculty research, disadvantaged U. S. citizens who are undergraduate and graduate student researchers, and technology transfer to the market place and to minority communities. The IRA (NRTS) is designed to improve the in-house capability of OMU's to electronically access science data and computational resources; to develop mechanisnis to support, sustain and evolve the network infrastructure of the targeted universities and colleges; and to make OMU's more effective in the competitive process for NASA and other science, engineering and technology funding opportunities. IRAs provide for the acquisition of research equipment and equipment essential to Internet connectivity.

The strategies for achieving the IRA (Research) goals include: (1) strengthening and improving core research areas of significance to the NASA mission; (2) increasing the number of students who are U. S. citizens conducting space research and working in NASA-related disciplines; *(3)* strengthening the research environment of eligible institutions and the capability of individuals by supporting the institutional infrastructure (through the acquisition of research equipment), faculty research, disadvantaged U. S. citizens who are undergraduate and graduate student researchers; and (4) technology transfer to the market place and to minority communities. To enhance the achievement of the above strategies, NASA has established an agency wide TRC for each of the selected IRA

(Research) recipients. The NASA TRC's are responsible for providing technical guidance to IRA (Research) recipients. NASA promotes collaboration between its funded IRA institutions, the Installations, JPL, and with entities outside of NASA. Institutions are encouraged to seek funding through NASA's traditional opportunities, as well as other government agencies and private sources. This is done in an effort to promote future sustainability. IRA s require substantial undergraduate and graduate student involvement in research projects.

The strategies for achieving the IRA (NRTS) goals include: (1) establish seven OMU's as lead NRTS; and (2) hold the lead OMU accountable for providing Internet connectivity to a minimum number of other OMU's and public schools, and for training students, faculty and teachers to build computers, maintain and effectively utilize the Internet to compliment teaching and research collaborations and delivery. The lead NASA Installation, Goddard Space Flight Center (GSFC), manages the IRA (NRTS) under the auspices of GSFC's Minority University - Space Interdisciplinary Network (MU-SPIN) Program. The Offices of Equal Opportunity Programs, Space Science, and Earth Science collaboratively provide funding and oversight for the GSFC MU-SPIN Program.

NASA Headquarters Program Offices, NASA Installations and JPL support both IRA programs through direct funding, use of their facilities, and commitment of their personnel to serve on TRC's and assist in other facets of program implementation. Students and principal investigators involved in both the IRA (Research) and IRA (NRTS) spend time on-site at the Installations and JPL throughout the year.

IRA **(Research)**

Universitv	Research Focus	Lead NASA Installation
California State University - Los Angeles	The Use of Decentralized Control in Design of a Large Segmented Space Reflector	Jet Propulsion Laboratory
Florida International University	High Performance Database Management with Application to Earth Sciences	Goddard Space Flight Center
University of Puerto Rico-Rico Piedras	Land Management in the Tropics and Its Effects on the Global Environment	Marshall Space Flight Center
The City College of New York	Tunable Solid State Laser and Optical Imaging	Langley Research Center
New Mexico Highlands university	Alliance for Nonlinear Optics	Marshall Space Flight Center

IRA **(NRTS)**

Universitv	Research Focus	Lead NASA Installation
The City College of New York	An Urban Collaboration for Network Connectivity and Internet Access	Goddard Space Flight Center
University of Texas at El Paso	UTEP NRTS	Goddard Space Flight Center

The goal of the **OMU Principal Investigator (PI) Awards** for Research is to provide faculty at OMU's, early in their careers, with an opportunity to integrate the research and education components of their careers with the unique mission requirements of a specific NASA Installation or JPL. By involving OMU faculty and students, NASA hopes to increase the interest of traditionally underrepresented communities in the Agency's mission and involve a broader array of America's citizenry in the NASA-sponsored research community.

The primary strategy for implementing the PI Awards for Research is through a competitive peer review and merit selection process in collaboration with the Strategic Enterprises, NASA Installations and JPL. Other strategies include: (1) Have discipline-related personnel at Headquarters and the NASA Installations and JPL be responsible for serving as points-of-contact for faculty interested in pursuing **an** award in this category: (2) Place responsibility for conducting the technical evaluations and making recommendations to Headquarters for funding consideration on the interested NASA Installation or JPL; ***(3)*** Provide funding to the nominating NASA Installation or JPL to make PI Awards for Research: and (4) Hold the NASA Installation or JPL responsible for managing the awards.

Each fiscal year, OMU's are invited to submit proposals for the Faculty Awards for Research (FAR). The FAR program provides for competitive, peer review selection of outstanding and promising engineering, physical and life science-tenured and tenure-track faculty at minority institutions early in their academic careers, who are capable of contributing to the Agency's research objectives and who have limited past NASA research grant experience, This award provides faculty members with sufficient research support and exposure to the NASA peer review process to enable them to demonstrate creativity, productivity. and future promise in the transition toward achieving competitive awards in the Agency's mainstream research processes. In FY 1996, these awards were expanded to include funding to involve graduate and undergraduate students in research projects.

The **OMU Math and Science Education Awards** focus on strengthening the capacity of OMU's to provide excellence in mathematics, science, engineering and technology (MSET) training while increasing the participation and achievement of disadvantaged students in MSET fields at all levels of education. Awards are made in the following areas: undergraduate and graduate; teacher preparation and enhancement; and, precollege activities.

MSET Awards contribute to the national education goals by supporting educational outreach projects at OMU's that increase the number and strengthen the skills, knowledge, and interest of students and teachers in mathematics, science, and technology-based academic programs. MSET awards, which consist of both unsolicited awards and solicited awards such as the "NASA Precollege Awards for Excellence in Mathematics, Science, Engineering and Technology (PACE/MSET) Program", will accomplish the following:

Undergraduate and Graduate Awards

Graduate students are provided scholarships, fellowships, internships, research opportunities in NASA-related fields, and other supportive services. In addition to the above, undergraduate students are provided access to tutors, mentors. and more group activities through the undergraduate awards.

The undergraduate projects identify high school seniors and continuing first-year students majoring in science, engineering, mathematics or computer science and provides student incentives through OMU's with proven records of recruiting, retaining, and graduating disadvantaged students in these fields. The students receive tuition support; are monitored, tutored and nurtured; and spend their summers conducting research with principal investigators at their universities, NASA Installations, federal laboratories or private industry. The NASA Installations and the JPL provide hands-on research experiences and mentors for those students. NASA requires active participation from the institutions, which provide student support services, faculty mentors, research experiences, additional tuition support as needed, and administrative support. It is expected that these students will form part of the pool from which NASA selects graduate researchers.

Teacher Preparation and Enhancement Awards
Under the Mathematics, Science, and Technology Awards for Teacher and Curriculum Enhancement Program (MASTAP), teacher and curriculum enhancement programs are designed to expand the number of teachers and strengthen their MSET skills to better enable them to integrate content from NASA's mission into middle and high schools' curriculum for presentation in schools with substantial enrollments of disadvantaged students.

Precollege Awards
Precollege students are provided with the necessary academic preparation and motivation to successfully complete challenging college preparatory MSET courses. These awards are intended to heighten students' interest and awareness of career opportunities in MEST fields and expose them to the NASA mission, research and advanced technology through role modals, mentors, and participation in research and other educational activities.

In addition to the award categories listed above and consistent with congressional direction and funding, NASA has initiated **OMU Partnership Awards** to "expand opportunities and enhance diversity in the NASA sponsored research and education community...achieve a balance between the proportion of NASA funding received by minority institutions of higher education and other institutions of higher education." One of the goals of the Partnership Awards is to strengthen NASA Installations' and JPL's partnerships with OMU's through projects which are unique and innovative, which fall outside of the usual MUREP competitive programs, and which have high potential for long-term support from other sources.

The NASA Installations and JPL are invited to jointly submit, with Presidents of Minority Universities, concept papers in three different categories: research; education; or combination research and education to Headquarters for competitive review and selection. Selected concept papers are expected to culminate in an award to an OMU. All concept papers must be responsive to the Agency's strategic direction; the federal mandates related to OMU's; and the NASA MUREP goals.

Additional funding was included in the conference report of the FY 1998 Appropriation Bill for VA-HUD-Independent Agencies to continue and expand the Partnership Award program. The $9.0M additional funding is to be equally divided between the HBCU and OMU programs.

NASA has established Technical Review Committees (TRC) to provide technical guidance and on-site reviews to recipients of IRA's and Research Center awards. NASA promotes collaboration between its OMU-funded programs, the Installations and JPL; and with entities outside of NASA. Institutions are encouraged to seek funding through NASA's traditional opportunities, as well as other government agencies and private sources. This is done in an effort to promote future sustainability. Research Centers, IRA's and

Principal Investigator (PI) awards require substantial undergraduate and graduate student involvement in research projects. The mathematics and science awards are normally managed by personnel at the NASA Installations and JPL.

MEASURES OF PERFORMANCE

Progress towards achieving OMU program goals is monitored through annual assessments of each award and the reporting of uniform research and education outcomes.

Additional metrics for the IRA (NRTS) will be designed to capture the technology and education focus of these awards. Specific metrics will include:

1) the number of OMU's and public schools connected to the Internet: and

2) the number of faculty, teachers and students trained to utilize the Internet to enhance research arid educational outcomes.

ACCOMPLISHMENTS AND PLANS

For the FY 1997 reporting period (Academic Year 1996–97 and Summer 1997), MUREP solicited research projects at OMU's, including 3 URC's, 5 IRA's, and 10 FAR's, reported the following outcomes. Research work was conducted by 148 professional-level investigators, including 104 faculty members, 27 research associates, and 17 postdoctoral fellows. A total of 356 students–212 undergraduates and 144 graduates--participated in these research activities. The research accomplishments were documented in 176 refereed papers or book chapters published during this time period. Significantly, 74 students were authors or co-authors of these publications. An additional 107 papers or book chapters, including 37 student authors or co-authors, were accepted for publication during this period. The broader research community was informed of this work through 375 technical presentations, including 152 presentations given by students.

During the reporting period, these projects were able to leverage their NASA MUREP funding of $9.5 million (including $2.3 million for students) to an additional $14.2 million in research support, $3.1 million from other NASA programs, and $11.1 million from other agencies. Technology transfer activities reported included 12 patents disclosed, applied for, or awarded: and 6 commercial products being developed or marketed.

A primary goal of OMU research programs is to increase the number of disadvantaged students receiving advanced degrees and entering into careers in NASA-related fields. Of the 356 students involved in these research projects during the reporting period, 212 (60%) participated at the bachelor's-degree level, 98 (28%) participated at the master's-degree level, and 46 (13%) participated at the doctoral-degree level. During the reporting period, 116 students obtained degrees: 64 bachelor's degrees: 42 master's degrees: and 10 doctoral degrees. Of these graduates, 83 percent were members of an under represented minority group.

University Research Centers (URCs)

The OMU Research Centers will enter their third year of funding during FY 1997. This group is funded at a maximum of $1.5M per year per research center for their first 3 years (including FY 1997). The planned funding has dropped to a maximum of $1.0M per year per research center for FY 1998 and FY 1999. Funding for the OMU research centers is primarily provided by the Strategic Enterprises in FY 1997 and totally in FY 1998 and FY 1999.

For the FY 1997 reporting period (Academic Year 1996–97 and Summer 1997), the *3* OMU Research Centers in the URC program reported the following outcomes. Research work was conducted by 57 professional-level investigators, including 45 faculty members, 9 research associates, and *3* postdoctoral fellows. A total of 156 students--86 undergraduates and 70 graduates--participated in these research activities. The research accomplishments were documented in 87 refereed papers or book chapters published during this time period. Significantly, 25 students were authors or co-authors of these publications. An additional 68 papers or book chapters, including 16 student authors or co-authors, were accepted for publication during this period. The broader research community was informed of this work through 252 technical presentations. including 121 presentations given by students.

During the reporting period, these projects were able to leverage their NASA MUREP funding of $4.7 million (including $1.1 million for students) to an additional $4.8 million in research support, $0.8 million from other NASA programs, and $4.0 million from other agencies. Technology transfer activities reported included 2 patents disclosed, applied for, or awarded: and 2 commercial products being developed or marketed.

A major goal of the OMU research centers is to increase the number of socially and economically disadvantaged and disabled students receiving advanced degrees and entering into careers in NASA-related fields. Of the 156 students involved in these research projects during the reporting period, 86 (55*Yo)* participated at the bachelor's-degree level, 58 (37%) participated at the master's-degree level, and 12 (8 *Yo)* participated at the doctoral-degree level. During the reporting period, 63 students obtained degrees: 38 bachelor's degrees: 20 niaster's degrees: and 5 doctoral degrees. Of these graduates, 90 % were members of an underrepresented minority group.

FY 1998 funding will continue the three Research Centers for a fourth year lo achieve a broad-based, competitive, core aerospace research capability among OMU's. Two new Research Centers will be awarded through a competitive peer review and selection process, and funded through the use of program office funds.

FY 1999 funding will support the three Research Centers for a fifth year. Plans to provide a second 5- years of funding will be announced. This will occur in similar fashion as to the way the HBCU Group I Research Centers were extended for a second 5-year period, Two Research Centers will receive second-year funding.

IRA (RESEARCH)

Six OMU's were selected to receive the first IRAs (Research) in FY 1994. One OMU award was canceled when substantial changes were made in the scope and direction of their selected research. The continuing IRA (Research) recipients were subjected to a comprehensive peer review during FY 1997. This review was conducted on-site by internal and external peer reviewers to collect not only the quantitative data but to also ascertain the qualitative results achieved. All five OMU's were eligible for continued funding in FY 1997.

IRA (Research)

University	Research Focus	Lead NASA Installation
California State University - Los Angeles	The Use of Decentralized Control in Design of a Large Segmented Space Reflector	Jet Propulsion Laboratory
Florida International University	High Performance Database Management with Application to Earth Sciences	Goddard Space Flight Center
University of Puerto Rico-Rio Piedras	Land Management in the Tropics and Its Effects on the Global Environment	Marshall Space Flight Center
The City College of New York	Tunable Solid State Laser and Optical imaging	Langley Research Center
New Mexico Highlands University	Alliance for Nonlinear Optics	Marshall Space Flight Center

IRA (NRTS)

University	Research Focus	Lead NASA Installation
The City College of New York	An Urban Collaboration for Network Connectivity and Internet Access	Goddard Space Flight Center
University of Texas at El Paso	UTEP NRTS	Goddard Space Flight Center

For the FY 1997 reporting period (Academic Year 1996–97 and Summer 1997), the 5 research IRA's at OMU's reported the following outcomes. Research work was conducted by 79 professional-level investigators, including 49 faculty members, 18 research associates, and 12 postdoctoral fellows. A total of 145 students--87 undergraduates and 58 graduates--participated in these research activities. The research accomplishments were documented in 75 refereed papers or book chapters published during this time period. Significantly, 35 students were authors or co-authors of these publications. An additional ***33*** papers or book chapters, including 17 student authors or co-authors, were accepted for publication during this period. The broader research community was informed of this work through 88 technical presentations, including 24 presentations given by students.

During the reporting period, these projects were able to leverage their NASA MUREP funding of $4.3 million (including $0.9 million for students) to an additional $8.8 million in research support, $2.2 niillion from other NASA programs. and $6.6 million from other agencies. Technology transfer activities reported included 9 patents disclosed, applied for, or awarded; and 4 commercial products being developed or marketed.

A major goal of the OMU research IRA's is to increase the number of disadvantaged students receiving advanced degrees and entering into careers in NASA-related fields. Of the 145 students involved in these research projects during the reporting period, 87 (60%) participated at the bachelor's-degree level, 29 (20%) participated at the master's-degree level, and 29 (20%) participated at the doctoral-degree level. During the reporting period, 36 students obtained degrees: 17 bachelor's degrees: 16 master's degrees: and 3 doctoral degrees. Of these graduates, 78 % were members of an underrepresented minority group.

In FY 1997, under the OMU IRA (NRTS) Program, 17 OMU's and K-12 public schools were connected to the Internet. Approximately 3,500 faculty, 3,300 administrative staff, and 13,600 students were trained to utilize the Internet.

FY 1998 funding will provide for five IRA (research), competitively selected in 1994, to receive fifth-year funding to continue research in areas essential to NASA's mission. Two IRA's selected as NRTS in FY 1995, will receive fourth-year funding to support and/or enhance access to science and technology research and education programs in the NASA-sponsored research and education community. One new IRA will be selected in collaboration with the Office of Space Science University-Class Explorer (UNEX) mission. This collaboration will foster OMU participation in NASA space science missions. The Office of Equal Opportunity Programs and the Office of Space Science have cooperated to build incentives for including OMU investigators in proposal teams for the UNEX Announcement of Opportunity to be released early in FY 1998. The selection criteria favor teams with significant OMU participation, and OEOP will provide up to $250K per selected project in capital investment funding (human resources, facilities, equipment, etc.) to further enhance the infrastructure of participating OMU's. One UNEX mission will be selected in FY 1998.

FY 1999 funding will provide two IRA's, selected as NRTS in FY 1995, to receive fifth-year funding to support and/or enhance access to science and technology research and education programs in the NASA-sponsored research and education community. The IRA selected in collaboration with the Office of Space Science UNEX mission **will** receive second-year funding and one new UNEX IRA will be selected.

Principal Investigator Awards For Research

For the FY 1997 reporting period (Academic Year 1996–97 and Summer 1997), 10 FAR projects at OMU's reported the following outcomes. Research work was conducted by 12 professional-level investigators, including 10 faculty members and two postdoctoral fellows. A total of 55 students--39 undergraduates and 16 graduates--participated in these research activities. The research accomplishments were documented in 14 refereed papers or book chapters published during this time period. Significantly, 14 students were authors or co-authors of these publications. *An* additional 6 papers or book chapters, including four student authors or co-authors, were accepted for publication during this period. The broader research community was informed of this work through 35 technical presentations, including seven presentations given by students.

During the reporting period, these projects were able to leverage their NASA MUREP funding of $0.6 million (including $0.2 million for students) with an additional $0.6 million in research support, $0.1 million from other NASA programs, and $0.5 million from other agencies. Technology transfer activities reported included one patent disclosure.

A major goal of the FAR program is to increase the number of socially and economically disadvantaged and disabled students receiving advanced degrees and entering into careers in NASA-related fields. Of the 55 students involved in these research projects during the reporting period, 39 (71%) participated at the bachelor's-degree level, 11 (20%) participated at the master's-degree level, and five (nine %) participated at the doctoral-degree level. During the reporting period, 17 students obtained degrees: 9 bachelor's degrees: 6 master's degrees: and 2 doctoral degrees. Of these graduates, 88 Yo were members of an underrepresented minority group.

In FY 1998, funding for 7 third-year, 4 second-year and 19 new FAR awards will be provided. FAR grants will be expanded to provide for research and student support and exposure to the NASA peer review process to enable them to demonstrate creativity, productivity, and future promise in the transition toward achieving competitive awards in the Agency's mainstream research activities,

In FY 1999, funding for 4 third-year, 19 second-year, and 17 new FAR awards will be provided, as well as funding for individual PI awards.

Efforts will continue to have the majority of OMU research selected for funding to be made through Competitive peer review and merit selection processes. Through more involvement in processes similar to FAR, it is expected that opportunities for participation in the Agency's mainstream research will expand as recipients' research capabilities are enhanced through interaction with NASA researchers and faculty. Additionally, the pool of disadvantaged students with research experience and interest in pursuing advanced degrees in the fields of science, engineering, and mathematics will increase through faculty support.

Math And Science Education Awards

The Math and Science Education Awards are composed of unsolicited awards and awards made based on solicitations. Primary funding supports the following four focus areas: undergraduate awards: graduate awards: precollege awards: and teacher enhancement and preparation awards.

For the FY 1997 reporting period (Academic Year 1996–97 and Summer 1997), 150 MUREP education and training projects were conducted at OMU institutions. The institutions conducted precollege and bridge programs, education partnerships with other universities and industry, NRTS, teacher training, and graduate and/or undergraduate programs. These programs reached a total of 23,748 participants. with the predominant number at the precollege level and achieved major goals of heightening students' interest and awareness of career opportunities in MSET fields, and exposing students to the NASA mission, research and advanced technology through role models, mentors, and participation in research and other educational activities. Also in FY 1997, NASA continued a very meaningful relationship with the Hispanic Association of Colleges and Universities (HACU) through Proyecto Access, a consortium through which HACU links seven HSI's together to conduct 8-week summer programs.

During the FY 1997 reporting period, grantees reported 4,334 high school students in NASA programs and 3,404 high school students selected college preparatory MSET courses, 349 high school graduates, 343 enrolled in college, and 199 selected MSET majors. There were 130 high school graduates (bridge students) in NASA programs and 19 students successfully completed their freshnian year. There were 307 teachers in teacher programs and 48 teachers received certificates. There were 151 undergraduate students, of which 29 received undergraduate degrees; and three studenls are employed in a NASA-related field.

There were 44 graduate students reported in the survey; six received Masters degrees, 23 continued for their next degree, one received a doctoral degree, and two students are employed in a NASA-related field. One student gave a presentation at a NASA Installation, one student had a publication published, and three students had publications accepted but are not yet published. Eighteen students gave presentations at national/international conferences, one student participated on a NASA panel and three students participated on a panel for another agency. Two commercial products are in the development stage.

The primary awards for the teacher enhancement and preparation awards is the Mathematics. Science, and Technology Awards for Teacher and Curriculum Enhancement Program (MASTAP). Teacher and curriculum enhancement progranis are designed to expand the number of teachers and strengthen their MSET skills to better prepare them to teach in middle and high schools that have substantial enrollments of disadvantaged students.

In FY 1997, the five OMU MASTAP's will be in their second year of a 3-year award. These programs have contributed to the National Education Goals by enhancing the ability of pre-service and in-service teachers to teach mathematics and science in schools underserved by NASA. This has been achieved through the development of special courses, cumculunis, instructional models, publications, presentation of academic papers, teacher certifications. Pre-service teachers have gained valuable classroom experience while at the same time providing extra attention to students in schools with large numbers of disadvantaged students. In the process, several teachers completed Masters Degrees. These programs have had a positive impact on both the universities that implement them and on the school districts with which they have partnered. The program is currently being reviewed with a goal to multiply the positive results of the impleniented programs. Effective and innovative instructional materials, curriculums and models developed by MASTAP programs will be distributed to a broad audience.

In FY 1998, the five MASTAP awards will be in their last year. Experience gained from the second set of MASTAP programs will be utilized in developing a new MASTAP solicitation to fund up lo six new OMU MASTAP awards in FY 1998. Measures and metrics will be revised and utilized in program evaluation. Efforts will continue to distribute effective instructional materials, curriculums, and models developed by MASTAP programs and a network of MASTAP Institutions, Principle Investigators, and past participants will be developed.

In FY 1999, funding will continue for a second year for up to six awards from FY 1998 and six new MASTAP Programs will receive funding. Mechanisms will be implemented to collect data to be utilized in evaluating programs against plans. All programs will participate in a program orientation. Efforts will continue to distribute effective instructional materials, curriculums and models developed by MASTAP progranis and to maintain and augment a network of MASTAP institutions, Principal Investigators and past participants.

In FY 1997, 8 OMU Precollege Awards for Excellence in Math, Science, Engineering and Technology (PACE/MSET) received continuation funding. In FY 1998, PACE funding will support five third-year, two second-year, and eight new OMU PACE/MSET awards. Of the seven second- and third-year grants, two are Tribal Colleges, four are Hispanic-Serving Institutions and one is a predominantly minority college. Through these PACE awards, primarily disadvantaged precollege and prefreshmen students are stimulated and challenged to excel in mathematics, science, engineering, and technology-based college preparatory courses. In FY 1999, PACE funding will support two third-year, eight second-year, and four new OMU PACE awards will replace expiring awards.

Partnership Awards

In FY 1997, more than 200 concept papers were received by the Agency in response to the solicitation for Partnership Awards. Twelve OMU's received a total of 21 awards. The OMU's were selected from 8 states and Puerto Rico. These awards are managed by the NASA Installations.

In FY 1998, the FY 1997 award will continue to be incrementally funded and at least two new awards will be selected. The goals of the new awards are to: 1) increase the number of undergraduate students with research training who earn MSET baccalaureate degrees and go on to enter graduate-level MSET degree programs or MSET-related careers; 2) foster the integration of NASA-related research into undergraduate education and promote undergraduate research training as an integral part of the undergraduate student experience: *3)* enhance research training by integrating discovery-based learning techniques throughout the MSET curricula: and 4) facilitate collaboration between the Minority Institution (MI) NASA-sponsored researcher and the MI MSET academic programs, and between the MI, NASA Installations and JPL, other institutions of higher education and the aerospace community having substantial involvement with NASA.

In FY 1999, funding will provide second-year funds for at least two awards, and replace expiring awards with 10 new awards.

Mission Support

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MISSION SUPPORT

FISCAL YEAR 1999 ESTIMATES

GENERAL STATEMENT

GOAL STATEMENT

The Mission Support appropriation provides funding for agencywide activities which are critical to NASA's mission success. This includes funding to: support NASA's civil service workforce; to provide critical space tracking and communications capabilities required by all missions: to conduct safety and quality assurance activities; engineering policies, standards, and guidelines: advanced concept studies: and for activities to preserve NASA's core infrastructure.

STRATEGY FOR ACHIEVING GOALS

Funding included in the Mission Support appropriation supports agency-wide activities which touch all of NASA's programs:

Safety, Mission Assurance, Engineering, and Advanced Concepts: This includes funding for programs to assure the safety and quality of NASA missions, through the development, implementation and oversight of agencywide safety, reliability, maintainability and quality assurance policies and procedures. It also includes funding for engineering policies, standards, and guidelines to improve analysis tools and test methods for design and verification of spaceflight systems, and study of advanced concepts for possible future technology development and mission use.

Space Communication Services: This includes funding for the operation of the tracking, telemetry, command, data acquisition, and communications and data processing activities that are required by all NASA projects. This includes the Tracking and Data Relay Satellite System (TDRSS),and the telecommunications system which provides for real time transmission of data, video and voice information between and among NASA installations.

Research and Program Management: This includes funding for the salaries, benefits, travel requirements and other support of the civil service workforce, and the necessary funding for all of NASA's administrative functions in support of research in NASA's field centers.

Construction of Facilities: This includes funding for the repair, rehabilitation, modification and construction of the institutional facilities, the environmental compliance and restoration program, and the advanced planning of facilities and design of future facilities.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MISSION SUPPORT

FISCAL YEAR 1999 ESTIMATES
(IN MILLIONS OF REAL YEAR DOLLARS)

	BUDGET PLAN		
	FY 1997	FY 1998	FY 1999
MISSION SUPPORT	2,564.0	2,388.2**	2,476.6
SAFETY, MISSION ASSURANCE, ENGINEERING, AND ADVANCED CONCEPTS	38.8	37.8	35.6
SPACE COMMUNICATION SERVICES	291.4	194.2	177.0
RESEARCH AND PROGRAM MANAGEMENT	2,078.5	2,033.8	2,099.0
CONSTRUCTION OF FACILITIES	155.3	122.4	165.0

** FY 1998 estimates reflect the effects of transferring funds from the enacted levels in P.L. 105-65 for the Mission Support (MS) and Science, Aeronautics and Technology (SAT) appropriations to the Human Space Flight (HSF) appropriation. A legislative proposal is being submitted for the purpose of providing transfer authority between the HSF appropriation and the MS and SAT appropriations.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

MISSION SUPPORT

For necessary expenses, not otherwise provided for, in carrying out mission support for human space flight programs and science, aeronautical, and technology programs, including research operations and support; space communications activities including operations, production and services; maintenance; construction of facilities Including repair, rehabilitation, and modification of facilities, minor construction of new facilities and additions to existing facilities. facility planning and design, environmental compliance and restoration, and acquisition or condemnation of real property, as authorized by law; program management: personnel and related costs, including uniforms or allowances therefor, as authorized by 5 U.S.C. 5901-5902; travel expenses; purchase, lease, charter, maintenance, and operatlon of mission and administrative aircraft; not to exceed $35,000 for official reception and representation expenses: and purchase (not to exceed *33* for replacement only) and hire of passenger motor vehicles; [$2,433,200,000] *$2,476,600,000,* to remain available until September 30. [1999] *2000.* (Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 1998.)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MISSION SUPPORT

REIMBURSABLE SUMMARY
(IN MILLIONS OF REAL YEAR DOLLARS)

	BUDGET PLAN		
	FY 1997	FY 1998	FY 1999
MISSION SUPPORT	**133.0**	**122.0**	**132.1**
SAFETY, MISSION ASSURANCE, ENGINEERING, AND ADVANCED CONCEPTS	.3	.2	.2
SPACE COMMUNICATION SERVICES	80.3	58.6	64.8
RESEARCH AND PROGRAM MANAGEMENT	49.2	60.2	64.6
CONSTRUCTION OF FACILITIES	3.2	3.0	2.5

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1999 ESTIMATES

DISTRIBUTION OF MISSION SUPPORT BY INSTALLATION
(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Centrr	Ames Research Center	Dryden Flight Research Center	Langley Research Center	Lewis Research Center	Goddard Space Flight Center	Jet Propulsion Lab	Headquarters
Safety, Mission Assurance,	1997	38,800	6,200	1,400	2,700	200	6,400	400	3,500	1,500	4,100	7.700	4.700
Engineering, and	1998	37,800	5.200	800	2,100	0	6.500	200	4,500	1,600	5,900	5.800	5,200
Advanced Concepts	1999	35.600	6.900	800	2,600	100	6.100	500	3,700	1,100	6.300	3,100	4.400
Space Communication	1997	291,400	4,200	0	56,130	0	0	0	0	17.900	206,661	5,500	1,009
Services*	1998	194,200	*0*	0	73,800	0	0	0	0	54.500	67.500	0	2,900
	1999	177,000	0	0	79.700	0	0	0	0	47,100	80.200	0	1,900
Research and Program	1997	2,078,500	349.979	295,219	297.778	43,191	168,386	45,656	208,950	196,188	313.492	0	219,661
Management	1998	2,033,800	332,389	225,364	282,821	40.753	168,077	53,628	215,354	193.542	325,191	*0*	196,681
	1999	2,099,000	336.659	221.184	290,569	45,924	169,508	57,213	221,219	197.800	339,424	0	219.500
Construction of Facilities	1997	152.289	17,901	9.821	22,009	5,171	12.005	13.228	7.829	19,350	24,106	16,092	4,687
	1998	118,895	4,903	15.284	22.224	12,350	5,220	6,897	7.557	15.240	14,469	11,754	2,901
	1999	161,760	11.790	30,390	31,110	11,100	13,600	2.520	10.550	17,670	18,940	13,750	2,340
Undistributed:													
Various locations	1997	3,011											
	1998	3,505											
	1999	3,240											
Total Construction of	1997	155,300											
Facilities	1998	122,400											
	1999	165,000											
TOTAL MISSION SIJPPORI'	1997	2,564,000	378,280	246,440	378,707	48.562	186,791	59.284	220.279	234,938	548,359	29.292	230,057
	1998	2,388,200	3342,582	241,448	380.945	53.103	173,797	00,725	227.411	264.888	413,060	17,554	207.682
	1999	2,476,600	355,349	252.374	403.979	55,124	189,208	60.233	2335.469	263,670	444,864	16.850	228.140

* - Includes an undistributed reduction of $4.5 million (FY 1998) and $31.9 million (FY 1999) to be taken within the fiscal yrar at the appropriate centers

Safety, Mission
Assurance, Engineering
and Advanced Concepts

MISSION SUPPORT

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF SAFETY AND MISSION ASSURANCE
OFFICE OF THE CHIEF ENGINEER
OFFICE OF THE CHIEF TECHNOLOGIST

SAFET MISSION ΛNCE, ENGINEER AND ADVANCED ?

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Policy. Oversight. and Standards	14900	13.800	16.600
Quality Management	10.000	8,600	4.600
Software Assurance	6.300	4.500	4.700
Advanced Concepts	--	5.000	4.400
Engineering	7.600	5.900	5.300
Total	38,800	37.800	35,600

Distribution of Program Amount bv Installation

	FY 1997	FY 1998	FY 1999
Johnson Space Center	6.200	5.200	6.900
Kennedy Space Center	1.400	800	800
Marshall Space Flight Center	2.700	2.100	2.600
Stennis Space Center	200	--	100
Ames Research Center	6.400	6.500	6.100
Dryden Flight Research Center	400	200	500
Langley Research Center	3.500	4.500	3.700
Lewis Research Center	1.500	1.600	1.100
Goddard Space Flight Center	4.100	5.900	6.300
Jet Propulsion Laboratory	7.700	5.800	3.100
Headquarters	4.700	5.200	4.400
Total	38.800	37.800	35.600

OFFICE OF SAFETY AND MISSION ASSURANCE
OFFICE OF THE CHIEF ENGINEER
OFFICE OF THE CHIEF TECHNOLOGIST

SAFETY, MISSION ASSURANCE, ENGINEERING. AND ADVANCED CONCEPTS

PROGRAM GOALS

NASA's Safety, Mission Assurance, Engineering, and Advanced Concepts (SMAE&AC) program is an investment in the safety and success of all NASA programs. The SMAE&AC program contributes to program safety and success by developing insight into NASA's programs and performing independent oversight. The program develops and issues necessary NASA-wide safety, risk management, and engineering policies, standards, and guidelines. Up-front quality management activities help reduce costs and improve safety and reliability by developing and piloting improved safety and mission assurance (SMA) tools to support better, faster, cheaper program development. Software assurance activities help ensure critical flight, ground control, and robotics system software performance by implementing NASA's software assurance improvement program: developing software assurance tools and techniques; and overseeing independent verification and validation (IV&V) for critical software. The SMAE&AC program through the Office of the Chief Engineer (OCE) promotes the use of national and international standards for spaceflight systems by improving design guidance for programs based on new technology and lessons learned. The program develops and demonstrates improved design, test, and validation methodologies for aerospace systems. This results in improved analysis tools and test methods for design and verification of spaceflight systems. It also results in enhanced systems engineering capability through integration of improved engineering tools and methods in the design process to take advantage of advanced computational environments. The SMAE&AC program through the Office of the Chief Technologist (OCT) also evaluates advanced aerospace concepts for feasibility and benefits.

STRATEGY FOR ACHIEVING GOALS

The SMAE&AC budget supports the activities of the Office of Safety and Mission Assurance (OSMA), the OCE, and the OCT. These three Offices advise the Administrator, oversee NASA programs, develop Agency-wide policies and standards, and support the technology requirements of NASA flight programs. OSMA leadership promotes and assures the safety and quality of all NASA programs. This is accomplished through program oversight and Agency-wide SMA policy and standards development. OSMA efforts in the Policy, Oversight, and Standards; Quality Management: and Software Assurance programmatic areas assist NASA's Strategic Enterprises in accomplishing their goals in a safe and efficient manner. OCE activities in the Engineering programmatic area provide a focus for NASA's engineering discipline, program implementation oversight, and improved engineering practices and capabilities. In addition to its technology leadership role, the OCT's Advanced Concepts area studies new and unconventional aerospace ideas that may be candidates for future development.

The Policy, Oversight, and Standards area addresses specific safety and mission assurance needs. This is accomplished by developing and promulgating necessary NASA-wide safety and risk management policies, standards, and guidelines as well as providing independent safety oversight and flight readiness assessments for NASA programs. Documentation and analysis of NASA experience in the SMA disciplines, mishap investigations, monitoring compliance with the Occupational Safety and Health Act, and emergency preparedness planning improve safety and risk management in NASA programs. NASA's implementation of ISO 9000 seeks to improve the quality of NASA's contracted work.

Up-front quality management activities focus on reducing costs and improving safety and reliability. This includes developing and applying methods and approaches to support "better, faster, cheaper" program development. SMA support to robotic spacecraft, aeronautics, and expendable launch vehicle programs are also included. Specific efforts in qualification test methods and non-destructive evaluation (NDE) technologies also support these goals. The electronic, electrical, and electro-mechanical (EEE) parts and packaging effort to qualify reliable high-performance components transfers to the Office of Space Science in FY 1999. This will facilitate better integration with overall customer technology development and qualification efforts.

The Software Assurance area supports the development of software assurance standards, practices, and technology to evaluate flight system, mission control, and science data system software. The goal is to assure the performance and reliability of increasingly complex and critical software used in NASA programs. Specific activities include implementing NASA's software assurance improvement program, developing tools and techniques, and overseeing IV&V of critical software.

The OCE, through the Engineering area, seeks to improve interoperability and reduce the costs of aerospace systems by developing NASA engineering standards and policies and using appropriate national and international standards. Improved practices for systems engineering, structural analysis, and test methods will increase the reliability and effectiveness of NASA programs.

The Advanced Concepts area investigates technology concepts and readiness issues for NASA's ten to twenty year strategic objectives.

MEASURES OF PERFORMANCE:

Metric	Description	FY 1997 Results
Mishap Prevention	Contribute to reducing the number of accidents at NASA facilities and lessening productivity losses.	In FY 1996, the lost time due to injury rate increased 13% from FY 1995 but remained 15% under goal and ½ that of comparable private sector industries. Property losses increased from $2 M to $5 M. These trends are not desired, but annual variability is expected and the variance remains within limits. FY 1997 data is not yet available.

Metric	Description	FY 1997 Results
Quality Management	Support for spacecraft projects and technology development to provide early risk management and quality studies for maximum benefit at project completion.	Risk management support provided to 12 projects. Streamlined mission assurance guidelines for New Millennium Program.
Systems Engineering	Improve and expand the use of integrated analytic methods to perform the systems engineering analyses required to define and optimize new missions and to ensure that development programs meet mission reauirements.	In FY 1997, development was completed on a decision support tool for integrated systems analysis that has been identified for transfer to industry. The OCE also established a Systems Engineering Forum to assess Agency-wide systems engineering capability
Independent Assessments, Oversight, and Reviews	Contribute to the safety and success of NASA missions by ensuring that programs have resolved all technical issues prior to flight. Evaluate adequacy of NASA SMAE&AC and Engineering capabilities; independently assess critical NASA issues.	OSMA supported eight Shuttle and five science payload launches, and is certifying the safety of Shuttle-Mir docking missions and crew transfers. The Independent Assessment (IA) for the International Space Station (ISS) analyzed technical design decisions and forwarded issues to the program. IA's findings reduce the potential for costly late-in-cycle redesign and improve future on-orbit safety and performance. OSMA managed the Interagency Nuclear Safety Review Panel (INSRP) process to certify the safety of the Cassini mission, which uses radioisotope thermal generators.
Program/Project Management Assessment	Support the Agency Program/Project Management process through independent assessment, Independent Annual Reviews and Non-Advocate Reviews for new program initiatives.	The Independent Assessment Program Office was established at the Langley Research Center and reviewed by the NASA Advisory Council. The office managed 24 assessments of ongoing and new programs and projects. The Office initiated five in-depth independent assessments and completed one. Development of the Advanced Collaborative Environment was initiated to link advanced development capabilities across the Agency.
Engineering Standards and Practices	Improve technical guidance used on NASA programs by integrating demonstrated technologies and lessons learned into Agency-wide standards that increase commonality and interoperability of NASA aerospace systems.	The OCE established a NASA-wide Technical Standards Database to promote use of common standards across the Agency, and initiated a process for adoption of national standards to meet NASA needs. Three handbooks were developed to address specific design issues and several NASA standards were advanced for international acceptance through ISO.

Metric	Description	FY 1997 Results
Safety and Quality Requirements and Standards	Replace NASA standards with US and international industry standards wherever possible. Develop and maintain NASA standards where required. Emphasize voluntary compliance and adoption of ISO 9000. Reduce cost of procuring flight and ground systems.	ISO 9000 has been adopted as the baseline quality standard and Center certification has begun: The content of OSMA directives has been reduced by 14%. Four documents have been completed under the new directives system. The newly developed "NASA Policy for Safety and Mission Success" addresses all SMA elements of a program. The Single Process Initiative is reducing costs by consolidating DoD and NASA requirements and audits at multi-customer plants.
Professional Development Initiative	Develop training materials to maintain SMA skills in a changing workforce.	Six instructor based modules, a Web-based training system, and 52 Web-based modules have been developed. The Web based system eliminates travel costs, reduces schedule conflicts, and dramatically reduces per-student costs.
Test Effectiveness	Provide environmental test data analyses correlated against flight performance to quantify specific guidance for tailoring test programs to specific mission requirements, thus enabling lower mission development costs for better, faster, cheaper spacecraft.	In-situ launch vehicle load, vibration, and acoustic environments have been measured. Historical environmental test and failure data is being compiled and analyzed. Development of guidelines for tailored test programs has begun.
EEE Parts and Packaging	Qualify advanced parts and packaging technologies to reduce size and power requirements for space flight systems. Facilitate use of most reliable components through development and use of parts selection databases.	Products include validation techniques and requirements for multi-chip modules, radiation hardness testing of commercial parts, and parts selection aids. Products also include process standardization for EEE parts and packaging evaluation. Evaluations included plastic encapsulation technologies, micro-ball grid array packaging, direct chip attachment, multi-chip modules, photonics, analog to digital converters, active pixel arrays, and digital signal processors.

Metric	Description	FY 1997 Results
Technology Leadership Council (TLC)	Ensure NASA-wide coordination of emerging technologies critical to future missions	The OCT held three TLC meetings during FY 1997 to establish Agency-wide directions and priorities. Results included identification of critical technology investment areas and industry sectors. In addition, charters and evaluation criteria for Centers of Excellence were developed and specific priority investment areas were identified for FY 1999.
Non-Destructive Evaluation (NDE)	Develop and certify improved NDE methods for aerospace manufacturing and operations. Reduce manufacturing and test costs by reducing teardowns, scrappage, and replacements caused by destructive testing.	Techniques in laser shearography, thermal emissivity, thermal diffusivity, and cable continuity were developed. A solid rocket booster nozzle inspection system and a cable continuity tester are in production use.

ACCOMPLISHMENTS AND PLANS

In FY 1997, OSMA assessed the safety and mission success inputs into the decision making processes for eight Space Shuttle missions, Shuttle Flight Operations Contract (SFOC) phase-in, and five major payload launches. The ISS IA identified technical issues. The IA findings and practical recommendations were provided to the ISS program to improve safety and performance. The ISS IA will also support OSMA decisions on flight readiness. OSMA reduced the volume of its directives by 14% in FY 1997 and completed four directives under NASA's new directives structure. The new "NASA Policy for Safety and Mission Success" provides a functional overview of all SMA requirements in one document and delineates the safety responsibilities of NASA's Enterprises. The Professional Development Initiative (PDI) completed a system of Web-based SMA training modules. These modules reduce per-student training costs. The PDI also provides contact information for other relevant NASA, government, and private sector education and training courses. ISO 9000 has been identified as NASA's baseline standard for quality management systems. ISO 9000 certification of NASA Centers has begun. OSMA instituted Center SMA Annual Operating Agreements (AOAs) in FY 1997. These AOAs document each Center's SMA products, services, resources, and metrics. The AOAs serve as planning, assessment, and requirements definition tools. The AOAs ensure that Center SMA organizations can deliver required value-added SMA support to customer programs and institutions. Process verification, OSMA's functional assessment of Center SMA process stability and capability, was initiated as a pilot activity. An easy-to-use electronic interface to the Shuttle Problem Reporting and Corrective Action system was piloted.

New Millennium, High Speed Civil Transport, Advanced Subsonics, and other programs received direct mission assurance support in FY 1997. OSMA developed streamlined mission assurance guidelines for the New Millennium program. Assurance guidelines were developed for common spacecraft devices and expendable launch vehicles. Load, vibration, and acoustic environments experienced by payloads during expendable vehicle launch were measured. Historical environmental test data continues to be compiled and analyzed to determine cheaper, less damaging, but effective test programs. Guideline development for space environmental testing is underway. NDE techniques in laser shearography, thermal diffusivity, thermal emissivity, and cable continuity were developed. A solid rocket booster nozzle inspection system and a cable continuity tester were certified and are in use on the shop floor.

OSMA's software assurance program funded the operation and maintenance of the Fairmont, WV, IV&V facility in FY 1997. The facility researched and developed autonomous spacecraft operations technologies, rapid software development processes, safety analysis, safety testing, and software reuse. The program continues to identify best practices in the field of software verification and validation. The program also provided tools, processes, and standards to help ensure that increasingly complex mission software safely performs as required.

In FY 1997 the OCE led the development of a commercial launch services acquisition policy. The OCE supported a risk assessment of the Pegasus-XL launch vehicle to enhance launch vehicle reliability and support mission success. The OCE provided leadership for development of a NASA Space Transportation Investment Strategy. This strategy established an integrated approach to define space transportation options for the future. The OCE established a Center-led program to implement consolidation of NASA standards and adoption of national/international technical standards. The Design, Test, and Verification (DTV) program, via a cooperative agreement with the FAA, extended the NASA fracture analysis methodology to aging aircraft and aircraft safety problems. The DTV program supported verification tests of the force limited vibration testing technique to additional payloads, and completed planning for a shuttle flight verification in FY 1998.

In FY 1997, the OCT supported the second year of Advanced Concept Research Program Fellows selected in FY 1996. The OCT initiated a competitive procurement to establish an external Advanced Concepts Institute (ACI). The ACI will complement the advanced concepts activities conducted within the NASA Enterprises. The OCT also established the TLC, comprised of senior NASA managers chaired by the Chief Technologist. The TLC provides coordination of NASA's technology activities and promotes effective communication of NASA's technology programs to the public.

OSMA's FY 1998 budget supports critical agency SMA infrastructure in order to maintain safety and mission success in the face of decreasing Agency resources and dramatic changes in business practices. Specific safety and mission assurance requirements in the new environment of "better, faster, cheaper" missions are addressed. Oversight of the Shuttle and Space Station programs is maintained. OSMA fully funds the ISS IA effort beginning in FY 1998. Once process verification data and techniques have ensured process stability and capability, new tools, techniques, and procedures will allow insight to replace audit-based oversight. Assurance for "better, faster, cheaper" missions will move from "rule-based'' to "knowledge-based'' approaches. Acquisition reform goals of efficiency and effectiveness are supported through the Single Process Initiative, ISO 9000, and performance-based contracting. OSMA supports the consolidated NASA ISO 9000 registrar contract for Center certification. The PDI and related training course development offers solutions to projected SMA skill mix problems. Six Shuttle flights and eight major payload launches will be supported. The SFOC performance will be evaluated. Updated standards and policies for electronic parts, reliability and maintainability, quality management systems, pressure vessel safety, metrology and calibration, and non-destructive evaluation will be completed. OSMA will launch a major effort to expand the use of risk management philosophies and techniques throughout the NASA program management structure. This effort parallels the roll out of NASA Policy Document 7120.5, "Program/Project Management".

The test effectiveness program and techniques for trading risk enable informed test planning for "better, faster, cheaper" missions and improved risk management in FY 1998. This effort includes measuring the actual load, acoustic, and vibration environment on different expendable launch vehicles. The development of advanced, unique NDE techniques will support less costly and longer life aerospace components. They include hydrogen/helium leak imaging, friction stir welding, electronics, and studies on probability of detection. These NDE techniques will support less costly and longer life aerospace components.

Product assurance support for "Instruments on Chip" will help lead to dramatically lighter and lower power electronics. The EEE parts and packaging effort will improve the mission reliability of rapidly evolving semiconductor technologies. These improvements will be accomplished by performing radiation screening for advanced new parts and establishing technology readiness for insertion of emerging technology into microspacecraft. Selection tools for commercial-off-the-shelf devices for "better, faster, cheaper" spacecraft and instruments as well as assurance for micro-electro-mechanical devices also support improved reliability. The evaluation of different vendor technologies for multi-chip modules, plastic encapsulation, micro-ball grid array packaging, direct chip attachment, analog to digital converters, active pixel arrays, and digital signal processors will occur.

The Software Assurance program continues to research, develop, pilot, and evaluate standards, tools, techniques, and processes in FY 1998. This will ensure the safe and reliable performance of critical mission software. Areas of emphasis include lifecycle risk, several safety issues, formal methods, and a reusable test bed. Operation and maintenance of the Fairmont, WV, IV&V facility is also supported.

In FY 1998, the OCE will expand the Langley Research Center (LaRC) mission concept and analysis capability and conduct independent reviews of selected programs. These reviews will include the Mars 2001 mission and the Bantam Lifter. The OCE standards program will expand cooperative projects with non-Government organizations that develop standards. The OCE will adopt voluntary consensus standards where practical and assess the potential to replace current Government standards with voluntary consensus standards. The Design, Test and Verification (DTV) program will continue refining and applying advanced analysis techniques to structural design. This will improve design margin management and increase system assurance. The OCE systems engineering program will extend international (ISO) product data exchange standards to space system applications, improving the tools available for design/development cooperation with industry and international partners.

In FY 1998, the OCT will support a long range Agency-wide activity to revolutionize the way NASA plans, analyzes, and develops future programs. Also in FY 1998 the Advanced Concepts Institute (ACI) will provide an independent, open forum for the analysis and definition of advanced space and aeronautics concepts. The ACI concepts will complement the advanced concepts activities conducted within the NASA Enterprises. The ACI will focus on revolutionary systems and architectural concepts that may have a major impact on future NASA missions. The scope of the ACI will include the National Space Policy, the NASA Strategic Plan, the NASA Enterprise Strategic Plans, and future mission plans of NASA Enterprises. The ACI will create an additional channel for advanced concepts to augment NASA Enterprise Strategic Objectives. The ACI will generate ideas for how the current NASA Agenda can be better performed.

In addition, the OCT will support efforts toward revolutionary changes in systems analysis capabilities. These activities will examine emerging technology advances in high data rate communications and networks, high performance computers, massively distributed data systems, advanced analysis methods, artificial intelligence and multimedia. Ultimately, these capabilities will enable widely distributed groups of experts covering diverse areas of science, technology and engineering to work as a highly integrated, virtually co-located team.

The TLC will serve as a forum for reviewing Agency policies, priorities, practices, and issues. The TLC will communicate and discuss technology goals and the national/international policies that guide their development. The TLC will coordinate the development of integrated strategic technology plans. The TLC will participate in the Agency process of developing recommendations for technology priorities and a budget for technology within NASA. Also in FY 1998, the OCE and the OCT will initiate a National Research Council assessment of NASA's engineering tool and methodology capabilities to support agency planning for capability improvements.

The OSMA assumes management and funding of contracted Shuttle IA efforts from the Office of Space Flight in FY 1999. The ISS IA continues to support the ISS program and OSMA flight readiness decisions. Eight Shuttle and nine major payload launches will be supported. Standards and policy streamlining and updating activities will continue. Risk management efforts ensure that NASA's program managers have the philosophy, tools, guidance, and expertise to make informed choices among technical, schedule, and cost risk. The PDI will continue to develop skills training modules to help maintain and improve the skills of the SMA workforce.

NDE technologies continue to be critical to ensuring safety in aging aircraft and reducing manufacturing and operational costs for advanced aerospace systems. Cryogenic flaw detection methods for composite tanks and eddy current techniques for corrosion detection will be completed. The EEE parts and packaging effort will be transferred to the Office of Space Science in FY 1999. OSS is the primary customer for assured high-performance parts, and the transfer enables better integration with their overall technology development and flight qualification efforts.

Beginning in FY 1999, operations and maintenance responsibility (and appropriate funding) for the Faimiont, WV, IV&V facility is transferred to the Office of Aeronautics. This transfer will complete the facility's transition to a component of the Ames Research Center. Development of standards, tools, techniques, and processes as well as pilot and evaluation activities continue. Technology transfer to software developers will help to ensure that safety and quality are built into critical software from the beginning.

In FY 1999, the OCE program for Engineering Standards and Practices will continue support for a "Preferred Standards" system for NASA. This system facilitates the consolidation of design practices and fully integrates use of national/international consensus standards in systems design, development and implementation. Standard program activity will include full participation in and cooperation with evolving national/international electronics networks for obtaining standards. International Product Data Standards (STEP) will be used in system design and analysis for structures, thermal systems and technical data packages. Demonstration of integrated test techniques to reduce cost and risk of space system testing will be expanded to shuttle payloads. The Independent Program Assessment Office at LaRC will have the capability to integrate Agency-wide design and analysis resources. This capability will be used to assess advanced concepts. It will also be used by the Enterprise programs to improve the quality and enhance the success of NASA missions.

The OCTs initiative to improve program planning, analysis, and development continues in FY 1999; focusing on systems analysis capabilities. Evaluation of data communications, high performance computing, multimedia, and artificial intelligence capabilities will enable future highly-integrated but geographically dispersed science and mission teams. The ACI will continue to define and analyze advanced aerospace concepts for possible future technology development or mission use. Findings will impact NASA's long-term planning. The TLC will continue as NASA's technology leadership and prioritization forum.

MISSION SUPPORT

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT — **SPACE COMMUNICATIONS SERVICES**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
Space Network	185,100	114,200	129,200	MS 2-4
NASA Integrated Services Network	106,300	84,500	79,700	MS 2-9
Pending Reduction	--	-4,500	-31,900	
Total	291.400	194.200	177.000	
Distribution of Program Amount bv Installation				
Johnson Space Center	4,200	--	--	
Marshall Space Flight Center	56,130	73,800	79,700	
Lewis Research Center	17,900	54,500	47,100	
Goddard Space Flight Center	206,661	67,500	80,200	
Jet Propulsion Laboratory	5,500	--	--	
Headquarters	1,009	2,900	1,900	
Pending Reduction	--	-4,500	-31,900	
Total	291,400	194.200	177.000	

PROGRAM GOALS

The Space Communications goal is to enable the conduct of the NASA strategic enterprises by providing telecommunications systems and services. Reliable electronic communications are essential to the success of every NASA flight mission, from planetary spacecraft to the Space Transportation System (STS) to aeronautical flight tests.

The National Space Policy stipulates that NASA will "seek to privatize or commercialize its space communications operations no later than 2005". The Space Operations Management Office (SOMO), located at the Johnson Space Center, manages the telecommunication, data processing, mission operation, and mission planning services needed to ensure the goals of NASA's exploration, science, and research and development programs are met in an integrated and cost-effective manner. In line with the National Space Policy, the SOMO is committed to seeking and encouraging commercialization of NASA operations services and to participate with NASA's strategic enterprises in collaborative interagency, international, and commercial initiatives. As NASA's agent for operational communications and associated information handling services, the SOMO seeks opportunities for using technology in pursuit of more cost-effective solutions, highly optimized designs of mission systems, and advancement of NASA's and the nation's best technological and commercial interests.

The Space Communications Services, one part of NASA's Space Communications program, is composed of the Space Network and NASA Integrated Services Network. These programs provide communications support to human space flight missions and low-Earth-orbital spacecraft and the Tracking and Data Relay Satellite (TDRS) system: to expendable launch vehicles and research aircraft; and for telecommunications interconnectivity among NASA flight support networks, project and the mission control centers, data processing centers, NASA Centers and facilities, contractor facilities, and investigator science facilities located throughout the nation and the world.

STRATEGY FOR ACHIEVING GOALS

The Space Communications program provides command, tracking and telemetry data services between the ground facilities and flight mission vehicles. The program also supports all the interconnecting telecommunications services to link tracking and data acquisition network facilities, mission control facilities, data capture and processing facilities, industry and university research and laboratory facilities, and the investigating scientists. The program provides integrated solutions to operational communications and information management needs common to all NASA strategic enterprises as well as NASA-wide telecommunications network services to support all of NASA's administrative communications needs.

The range of telecommunications systems and services are provided to conduct mission operations, enable tracking, telemetry, and command of spacecraft and sub-orbital aeronautical and balloon research flights. Additionally, services and systems are provided to facilitate data capture, data processing, and data delivery for scientific analysis. The program also provides the high speed computer networking, voice and video conferencing, fax, and other electronic mail services necessary to administer NASA programs.

These communications functions are provided through the use of space and ground-based antennas and network systems, mission control facilities, computational facilities, command management systems, data capture and telemetry processing systems, and a myriad of leased interconnecting communications systems ranging from phone lines and satellite links to optical fibers.

The program provides the necessary research and development to adapt emerging technologies to NASA communications needs. New coding and modulation techniques, antenna and transponder development, and automation applications are explored and, based on merit, demonstrated for application to future communications needs. The program also provides scheduling, network management and engineering, pre-flight communications test and verification, as well as flight system maneuver planning and analysis for selected missions. NASA's flight programs are supported through the study and coordination of data standards and communication frequencies to be used in the future. These are all parts of the strategic approach to providing the vital communications systems and services common to all NASA programs and to achieve compatibility with future commercial satellite systems and services.

Many science and exploration goals require inter-agency or international cooperation in order to be achieved. NASA's Space Communications assets are provided through collaborative agreements to other U.S. Government agencies, commercial space enterprises, and international cooperative programs. Consistent with the National Space Policy, NASA will purchase commercially available goods and services to the fullest extent feasible, and will not conduct activities with commercial application that preclude or deter commercial space activities.

The modernization of the original White Sands Ground Terminal, Cacique, coupled with its twin, Danzante. provided fail-safe operations of the Space Network and its TDRS spacecraft. Initial planning and design of a remote ground terminal capability at Guam, extending the White Sands Ground Terminal capability by providing for coverage of the Zone of Exclusion, was completed in FY 1996. Development of the system is continuing with completion of the system in FY 1998. The Space Network provides communications for the Space Transportation System, the Hubble Space Telescope (HST) astronomical observatory and many other NASA missions, as well as for non-NASA users on a reimbursable basis. The development of the Replenishment Tracking and Data Relay Satellites is on-going. The Telecommunications program consolidated all NASA wide-area network systems in FY 1997, providing integrated services for operational and administrative communication needs at reduced costs.

Efforts are ongoing to consolidate and streamline major support contract services in order to optimize space operations. Transition to a Consolidated Space Operations Contract (CSOC) is planned in FY 1998. The CSOC acquisition process is being implemented in two phases. Two 8-month fixed-price study contracts were awarded to Boeing North American and Lockheed Martin, Incorporated on May 16, 1997 to develop an Integrated Operations Architecture (IOA). The IOA and a proposal to implement the architecture are due to NASA in January 1998. NASA intends to award a single cost-plus-award-fee contract to implement the IOA and to provide space operations services during a five-year basic contract, with a five-year option. The 90-day phase-in period is planned to start on July 1, 1998. This full and open competition is expected to produce efficiencies and economies over the life of the contract which benefits all NASA programs. Specifically, the integrated architecture is expected to maximize space operations resources by reducing systems overlap and duplication. Efforts are ongoing to develop a Space Operations pricing policy, including the pricing of contractor provided services and how each Enterprise will pay for services. In addition, the Agency's pricing policy will be incorporated under the CSOC and full-cost accounting . Programmatic content in FY 1999 will be reduced by $31.9 Million. The impacts of this reduction has not yet been identified, however, it is anticipated that the overall cost of space operations services (Space Communications Services and Mission Communication Services) will be reduced with the advent of the Consolidated Space Operations Contract (CSOC) beginning in FY 1999. In addition, efforts will be undertaken to consider opportunities to accelerate the National Space Policy directive that NASA seek to privatize or commercialize its space communications operations no later than 2005.

BASIS OF FY 1999 FUNDING REQUIREMENT

SPACE NETWORK

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Space Network Services	5,100	3,700	8,800
TDRS Replenishment Spacecraft	162,100	61,000	73,300
TDRS Replenishment - Launch Services	17,900	49,500	47.100
Total	185.100	114.200	129.200

PROGRAM GOALS

The Space Network program goal is to provide reliable, cost-effective space-based tracking, command and data acquisition telecommunications services to the Human Space Flight program, other low-Earth-orbital science missions including observatory-class flights, and selected sub-orbital flight missions. The Space Network program provides for the implementation, maintenance, and operation of the communications systems and facilities necessary to ensure and sustain the high-quality performance of NASA flight operations systems. Replenishment Tracking and Data Relay Satellites and the launch systems required to deploy them are also included in this program.

The Space Network participates in collaborative interagency and international programs, and independently provides communications services to other national and commercial endeavors on a reimbursable basis.

STRATEGY FOR ACHIEVING GOALS

NASA's Space Network is comprised of a constellation of geosynchronous TDRS and associated dual ground terminals located in White Sands, New Mexico. The current TDRS constellation consists of three fully operational satellites in service (TDRS-4, 5, & 7), one fully functional satellites stored on-orbit (TDRS-6), and two partially functional spacecraft (TDRS-1 & 3). TDRS-3 is positioned over the Indian Ocean, in conjunction with a remote terminal in Australia, to increase data return from the Compton Gamma Ray Observatory (CGRO) and support Shuttle/MIR operations. TDRS-1, now in its fourteenth year, is still providing service to expendable vehicle launches and other peak loads in the eastern network node.

The Goddard Space Flight Center manages the Space Network program, including the TDRS Replenishment Spacecraft program, and the modification and/or system replacement of the ground facilities and equipment as necessary to sustain network operations for current and future missions. The Replenishment Spacecraft program will provide three TDRS spacecraft under a fixed-price, commercial practices contract. The prime contract was awarded to the Hughes Space and Communications Company in 1995, and development is now under way. The first spacecraft's launch readiness is scheduled for the third quarter of CY 1999. The program provides for spacecraft compatibility modifications to the New Mexico ground terminals. Lockheed Martin Corporation is the prime contractor for launch services for the TDRS Replenishment Spacecraft.

The AlliedSignal Technical Services Corporation and the Computer Sciences Corporation are the primary support service contractors responsible for maintenance and operations of the ground terminal facilities and orbital operations of the spacecraft as well as engineering and test support. The two contractors established a voluntary partnership in 1996 for these services under the Consolidated Network and Mission Operations Support (CNMOS)performance-based contract.

The Space Network provides communication services at data rates up to 300 megabits-per-second (MBPS)using its Ku-band single-access services, data rates of up to three MBPS using its S-band, single-access services, and a low-rate service of up to 50 kilobits-per-second (KBPS) through its multiple-access service. These services provide unparalleled, flexible high-data-rate communications capabilities for flight operations of low-Earth-orbital missions. Customer satellites are provided with command, tracking, and telemetry services via the TDRS spacecraft, which act as relays for commands from and science telemetry return to the ground terminals. The ground terminals are interconnected with flight control, data capture and processing facilities responsible for mission operations.

Communications services are provided to non-NASA customers on a reimbursable basis. A large share of the Space Network Services program that provides for the operations and maintenance of the ground terminal complex is funded with the receipts from reimbursable services. This reimbursable revenue is anticipated to continue and has been taken into account in formulating the NASA FY 1999 budget request.

Space Network services provide the primary communications for orbital operations of the Space Transportation System and its attached payloads. Services are also provided to automated Earth-orbital missions which have communications systems compatible with the TDRS, and can provide nearly continuous high-data-rate services. The Space Network will provide communications services for the International Space Station (ISS) beginning in FY 1998. Services will also be provided on an agreed-to basis to NASA's International partners. Agreements are in place with Japan, the European Space Agency, and Canada. Negotiations are continuing with the Russian Space Agency as a participant for potential cooperative endeavors in telecommunications.

In addition to the day-to-day operations of the Space Network satellites and ground terminals, the program provides for the replenishment of the satellite assets.

MEASURES OF PERFORMANCE

	FY 1997 Plan	FY 1997 Actual	FY 1998 Plan	FY 1998 Current	FY 1999 Plan
Number of hours of network service	27,000	44,000	35,000	60,000	78,000

The projected output of network services will remain relatively level until FY 1998. The initiation of ISS assembly, and the launch of Earth Observation System (EOS)AM-1 and Landsat-7 will necessitate an increased level of communications services. In FY 1999, full-up support to the ISS will necessitate further increase in the level of communications services.

TDRS Replenishment Spacecraft

Contract Award
Plan: February 1995
Actual: February 1995

Early design activities began in April 1995. The contract was awarded on schedule, but initiation of activity was delayed due to a protest, which was resolved by GAO in July 1995.

Preliminary Design Review
Plan: July 1996
Actual: July 1996

The review verified that the proposed contractor design will meet NASA performance requirements.

Critical Design Review (CDR)
Plan: January 1997
Actual: June 1997

The review verified that the contractor was prepared to proceed with the manufacturing, assembly, integration, and testing of the TDRS spacecraft. CDR was rephased due to the delay in the development of engineering models as a result of the lack of contractor resources and late requirements flow down. The schedule was replanned with no impact to the compleltion of the TDRS-H integration and test.

Start TDRS-H Integration and Test
Plan: May 1997
Actual: December 1997
TDRS-I: April 1998
TDRS-J: June 1998

Start of spacecraft assembly, as well as electrical, environmental, and performance testing. The process begins with spacecraft and with spacecraft-level assembly and test. The TDRS-H integration and test was rephased due to the delay in the development of engineering models. The TDRS-H was replanned with no impact to the planned launch date.

Pre-Environmental Review

Verification that the spacecraft is ready for system level environmental testing.

Plan: TDRS-H July 1998
Plan: TDRS-I October 1998
Plan: TDRS-J February 1999

Complete Integration and Test Plan: TDRS-H January 1999 Plan: TDRS-I May 1999 Plan: TDRS-J September 1999	Completion of spacecraft performance and environmental tests allows final assembly and re-testing to begin prior to shipment for launch.
Launch TDRS-H Plan: 4rd Qtr FY 1999	Launch within four years of contract award will be performed, ensuring the continuity of TDRSS services to user space flight systems. Launch of TDRS-I and TDRS-J is scheduled for 2002 and 2003 following the launch of the first TDRS Replenishment Spacecraft.

CONSOLIDATED SPACE OPERATIONS CONTRACT (CSOC)

Phase 1 Contract Award	May 1997
Phase 2 Proposal due	Jan 1998
Phase 2 Contract Award	Jun 1998
Phase 2 Phase-In	3rd QTR. 1998
Phase 2 CSOC In Force	OCT 1998

ACCOMPLISHMENTS AND PLANS

The Space Network is required to operate 24 hours per day, 7 days per week, providing data relay services to many flight missions. These missions include eight planned Space Shuttle flights and their attached payloads, observatory-class spacecraft in low-Earth orbit such as HST and the CGRO, as well as other compatible missions such as Ocean Topography Experiment, Extreme Ultraviolet Explorer (EUVE), Department of Defense customers, the X-ray Timing Explorer (XTE), the Starlink research aircraft, and the Long Duration Balloon program. The Space Network extended service (on a reimbursable basis) to the expendable launch vehicle community including agreements with US Air Force Titan and Lockheed Martin's commercial Atlas programs.

The Space Network will continue to provide services to the Space Shuttle Flights and their attached payloads, as well as the construction phase of the International Space Station, LANDSAT-1, ETS-VII, TRMM, and the Earth Observation System AM-1 mission.

Efforts began on the establishment of a more robust remote terminal capable of full service provision to users in the TDRS zone of exclusion. The implementation of a full service remote terminal on Guam began with the approved FY 1995 Operating Plan reprogramming action late in FY 1996. The Guam Remote Ground Terminal (GRGT)development will continue with site development at a U.S. Navy location in Guam. The GRGT extends the capability of the White Sands Ground Terminals to provide full service coverage in the former Zone of Exclusion. This terminal is scheduled to be operational in mid-FY 1998 and will replace the current, less capable terminal located in Australia. This remote terminal has already proven invaluable in boosting the scientific return from the Compton Gamma Ray Observatory.

Preliminary engineering studies were initiated to add Demand Access capability which would allow customers to directly obtain services from the Space Network without scheduling. Demand access will be installed at White Sands and will be available for customer use in mid-FY 1999.

Development activities for the TDRS Replenishment Spacecraft continued: The spacecraft Critical Design Review was held in June 1997. The launch services contract was definitized for TDRS-H and mission integration activities have been initiated. Spacecraft to launch service interfaces and interface requirements were identified and will be finalized by mid-FY 1998. Compatibility of requirements and launch vehicle performance will be established and contractually documented for the TDRS-H mission. Manufacturing of the TDRS-H launch vehicle hardware will begin in mid-FY 1998. Integration and test activities associated with TDRS-H, I, and J will be completed. TDRS-H will be launched in late FY 1999. Modifications to the White Sands Complex ground support in preparation for TDRS-H, I, J spacecraft support will begin.

BASIS OF FY 1999 FUNDING REQUIREMENT

NASA INTEGRATED SERVICES NETWORK (NISN)

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
NASA Integrated Services Network	106,300	84,500	79,700

PROGRAM GOALS

The NASA Integrated Services Network Project's (NISN) goal is to provide high-quality, reliable, cost-effective telecommunications systems and services for mission control, science data handling, and program administration for NASA programs. NISN provides for the implementation, maintenance, and operation of the telecommunications services, control centers, switching systems, and other equipment necessary to provide an integrated approach to NASA communication requirements.

NISN supports NASA's programs in collaborative interagency, international, and commercial enterprises. Many collaborative arrangements are performed on a reimbursable basis.

STRATEGY FOR ACHIEVING GOALS

NISN is a nationwide system of leased voice, video, and data services: leased wide-band terrestrial and satellite circuits; and control centers, switching centers, network equipment and other communications devices. International telecommunications links are also provided to NASA's Deep Space Network (DSN) sites in Australia and Spain: Spaceflight Tracking and Data Network (STDN) sites outside the Continental US.; and common telecommunications exchange points that provide interconnectivity to NASA international partners. Administrative, scientific, and mission control exchanges among NASA and its industrial and scientific partners are supported by NISN's telecommunications networks and systems. Support and participation by other US agencies, universities, and research centers, and by other space-faring nations, are also facilitated, including the provision of secure circuits, systems, and facilities. Domestic telecommunications circuits are primarily leased by NASA under the FTS-2000 contract managed by the General Services Administration; international circuits are leased under separate contractual arrangements. NISN maintains cooperative networking agreements for exchanging services with the European Space Agency (ESA),Canada, Japan, France, and Russia. The Computer Science Corporation provides engineering and operations support for NISN.

NISN is managed by the NISN Project Office at Marshall Space Flight Center, in partnership with the Goddard Space Flight Center. NISN provides unique mission and mission support telecommunications services to all NASA Centers, supporting contractor locations, international partners, research institutes, and universities.

Command, telemetry, and voice systems communications are provided between spacecraft mission control facilities, tracking and data acquisition networks, launch sites, NASA data processing centers, and scientific investigators whose support is critical to mission control and command. NISN supports NASA aeronautical test sites, as well as preflight verification of NASA spacecraft systems and their interconnectivity with NASA communications systems.

The NISN interconnects NASA installations and national and international aerospace contractors, laboratories, scientific investigators, educational institutions, and other Government installations in support of administrative, science data exchange, and other research and analysis activities. Specific mission-support services provided by the NISN are voice and video teleconferencing, broadcast television, computer networking services, as well as data handling and transfer services including Internet connectivity.

NISN provides for the improvement, operation and maintenance of NASA network systems and facilities. Telecommunications network systems include digital voice: data and video switching equipment: audio and video conferencing and bridging systems: wide-band multiplexing equipment: and sophisticated network management, monitoring and fault isolation systems. Equipment and facilities of NASA Select Television are also provided by NISN.

Telecommunications services are rapidly developing and maturing. With the advancements of telecommunications technology and standards, NASA telecommunications services are now more readily available from commercial sources. NISN continually analyzing current telecommunications requirements to determine the feasibility of providing NASA telecommunications services through commercial sources. NISN also maintains a close relationship with the NASA Research and Education Network (NREN),NASA's research and development network, to determine what information technologies are beneficial to support NASA's growing telecommunications needs. As technologies become standard and commercially available, NISN conducts study and cost analyses to determine the feasibility of purchasing these services for use by the NASA community.

MEASURES OF PERFORMANCE

	FY 1997		FY 1998		FY 1999
	Plan	Actual	Plan	Current	Plan
Number of locations connected	400	398	450	410	420
Number of electronic conferences	31,500	41,000	34,500	45,000	48,000

Constrained travel budgets continue to increase the number of electronic conferences supported within NASA. As more program and administrative services, such as Consolidated Supercomputer Management and Integrated Financial Management Programs, are consolidated to one center, reliance on the networking services increases. Users no longer have "center"resources, but are accessing consolidated Agency resources across the NISN network. This has resulted in increased network connections.

ACCOMPLISHMENTS AND PLANS

NISN finalized the planning and implementation activities for the commercialization of the Video Teleconferencing Service, the Voice Teleconferencing Service, and transmission connectivity for the NISN Routed Data Service.

Transition of the NISN Video Teleconferencing Service the General Services Administration's Federal Telecommunications Services (FTS) 2000 Switched Compressed Video Transmission Service (SCVTS) began in FY 1997. This video service is shared by several government agencies, provides connectivity to commercial video services such as those provided by Sprint and MCI, and is also compatible to desktop video systems. This transition standardizes NASA video teleconferencing service on the industry standard of voice activated switching, and provides greater access to non-NASA video systems.

A business case and industry study was completed on the Voice Teleconferencing Service. It was determined that this service could be provided via a commercial resource and a Request for Proposal (RFP)was developed. Proposals were received from industry and evaluated for potential vendors for the service.

Based on the NISN business case developed with information from FTS2000 service providers, it was determined that the transmission connectivity for the legacy routed data networks, PSCNI. NSI, and AEROnet, could be consolidated and provided technically and cost effectively over an Asynchronous Transfer Mode (ATM)infrastructure. FTS2000 Network B, provided by Sprint, was determined to be the best method for the provision of this service. One of the main reasons proved to be the existing NREN connectivity, also provided by Sprint via a separate government contract, at five of the main NASA centers. NISN and NREN, through a MOU, agreed to share these services, resulting in a cost savings to NASA as well as providing a technical avenue for NISN and NREN to collaborate on advance technology activities. The planning and scheduling for the transition of this activity was completed in FY 1997 and implementation is planned for FY 1998.

The implementation of support for the Mission IP service has been completed and several Space Shuttle mission have been supported using the Mission IP service in a shadow mode, with the legacy systems in the primary mode.

In addition to these activities, NISN also made considerable progress on the downsizing of the NASA Packet Switching System (NPSS),a legacy X.25 network. Extensive coordination with customers of this service was conducted and alternative methods for these customers to access their applications were identified. As customer services have been disconnected at a NASA center, the NPSS service at that center has been downsized to only support legacy network monitoring.

NISN also completed a study to evaluate the remaining services on the NISN backbone network, and conducted requirements reviews with the International Space Station Program.

NISN completed the transition of the Routed Data Service to the ATM service provided by FTS2000/Sprint. NISN will prepare and implement a plan to optimize the Routed Data Service to further consolidate the service. The implementation of support for the Integrated Financial Management and Consolidated Supercomputer Programs will be analyzed and additional resources will be obtained to support these requirements. A study will also to be developed to determine if the complete NISN Routed Data Service, both mission and mission-support, can be provided via commercial providers.

NISN completed the support of one Shuttle mission with the Mission IP service in the primary mode. NISN will complete this support during the mid-January Shuttle mission, to complete the acceptance period for Mission IP service.

NISN will continue to analyze commercial services for potential use in meeting NASA's expanding Mission Requirements. appropriate telecommunication services. NASA will be adding services in support IFMP, COSMO, ISS Phase II, National Oceanic and Atmospheric Administration (NOAA)-K, Earth Observation System, Advanced Composition Explorer (ACE),Advanced Earth Observing Satellite (ADEOS)and TRMM. NISN will complete the test phase of the Video Teleconferencing Service Transition to FTS2000 and accept that service as operational. In addition, NISN will complete an upgrade to the Full Service Video Teleconferencing Room systems.

NISN will award a contract to commercialize the Voice Teleconferencing Service and transition to the new service. NISN will complete the NPSS downgrade project and will begin the downgrade of the legacy DS-3 backbone network as the Routed Data Service and Video Teleconferencing service transitions are completed. NISN will add additional capacity and services to the Russian telecommunications infrastructure in order to support the Phase II International Space Station requirements. These will include additional video teleconferencing, routed data, and local area connectivity to the Moscow Mission Control Center and the Gagarin Cosmonaut Training Center. Extensive Routed Data connectivity will be added to NISN to support the Mission to Planet Earth activities during the period.

Research and Program
Management

MISSION SUPPORT

FY 1999 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

PROGRAM GOALS

To acquire and maintain a civil service workforce and infrastructure which reflects the cultural diversity of the Nation, which is properly sized and which possesses the right set of human resource skills in the right locations to accomplish NASA's research, development, and operational missions with innovation, excellence, and efficiency.

STRATEGY FOR ACHIEVING GOALS

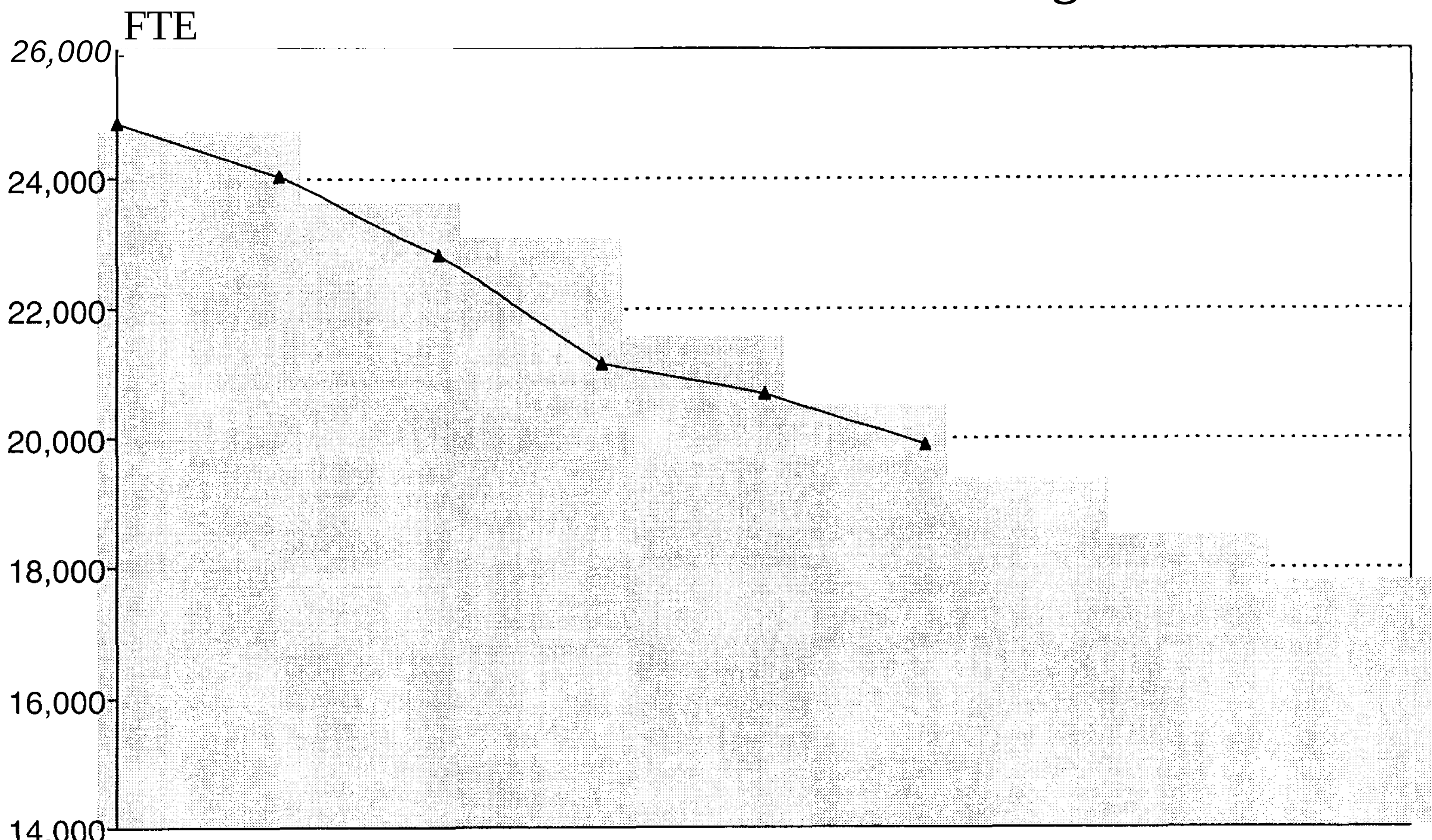
This civil service workforce is the underpinning for the successful accomplishment of the Nation's civil aeronautics and space programs. These are the people who plan the programs: conduct and oversee the research: select and monitor the contractors: manage the various research, development, and test activities: and oversee all of NASA's operations. A key dimension of the reinvention of NASA has been the restructuring of the civil service workforce to deliver a space and aeronautics program that is balanced, relevant, and at the forefront of technology development. By the end of FY 2000, NASA plans to have restructured the size and composition of the workforce to fewer than 18,000 civil servants, nearly a 30 percent reduction from the authorized FY 1992 levels of just over 25,000. Despite the fact that such reductions far exceed expected natural attrition, the Agency is working aggressively to achieve these reductions without resorting to a disruptive reduction in force. The primary strategies involved include reduced hiring, extensive but managed use of the Agency's buyout authority, geographic relocations, and the provision of outplacement services.

The Research and Program Management (R&PM) program provides the salaries, other personnel and related costs, travel and the necessary support for all of NASA's administrative functions and other basic services in support of research and development activities at NASA Installations. The salaries, benefits, and supporting costs of this workforce comprise approximately 75% of the requested funding. Administrative and other support is 23% of the request. The remaining 2% of the request is required to fund travel necessary to manage NASA and its programs.

ACCOMPLISHMENTS AND PLANS

Once again NASA has achieved the full-time equivalent (FTE) targets included in the NASA Workforce Restructuring plan for FY 1997 ahead of schedule. The Agency continued to make progress towards specific workforce goals established by the National Performance Review (NPR). These goals were met ahead of schedule through the implementation of the most restrictive hiring policy in recent years and the buyout conducted in FY 1997. The successful buyout used early in FY 1997 resulted in more than double the normal annual attrition. As a result, the Agency used only 19,883 FTE compared to its original plan of 20,501. A particularly noteworthy achievement is the continued reduction to the infrastructure at

NASA FTE Civil Service Reduction Plan
With End of Fiscal Year Actual Usage Rates



	FY 93	FY 94	FY 95	FY 96	FY 97	FY 98	FY 99	FY 00
FTE Limit	24,731	23,623	23,075	21,555	20,501	19,364	18,519	17,818

Does not include the **NASA** Office of Inspector General

Headquarters through the aggressive redeployment of Headquarters personnel to the Field Installations and losses through attrition. As a result, the Agency has reached the NPR goal of a reduction by 50% more than 3 years ahead of schedule, and did it without resorting to a reduction in force. At the Field Installations, operational activities continue to be transferred to commercial operators or to other Federal agencies where feasible. Civilian employment at the end of FY 1997 was about 19,900, a reduction of about 4,792 or 20% since 1993.

The Agency also successfully met the other goals for FY 1997 established as part of the NPR:

- The supervisory span of control has gone from 1:5 in FY 1993 to 1:9 in FY 1997.
- Targeted administrative staffs have declined more than 24% from FY 1993 levels.
- Headquarters employment has been reduced by more than 1,100 or 50% from FY 1993.

The NASA workforce target for FY 2000 is fewer than 18,000 FTE, Achieving the remaining reduction of more than 1,500 civil servants from the FY 1997 level represents a formidable objective. NASA has stressed, and will continue to stress, the need to minimize adverse impacts on the workforce. The plan is to aggressively use all available voluntary approaches to reductions for as long as possible before employing involuntary methods.

Central to this strategy in FY 1998 and FY 1999 is once again implementation of an aggressive buyout plan to (1) achieve at least double the number of losses expected under the normal attrition: (2) reach the FTE targets for FY 2000 by the beginning of FY 1999 at as many Field Centers as possible. Each NASA Center has structured their buyout planning based on the results of comprehensive workforce assessments and their Workforce 2000 strategic plans. These plans identify the Center of Excellence and Mission for the Center, its restructuring strategy, and the number and skill mix of positions required for FY 2000. Each Center has focused its plans for the buyout at their site based on consideration of what types of positions would be in excess in the future. Cost associated with the buyout, including required payments to the retirement fund are included in these budget estimates. The Agency approach, as well as a summary by Center, is included in the Agency's workforce restructuring plan, which will be submitted to Congress in late February once details for FY 1998 buyout plans are finalized.

The FY 1999 budget estimate of $2,099.0 million for Research and Program Management represents a continuation of the aggressive downsizing NASA has undertaken since FY 1993 and incorporates the reduction associated with the planned FY 1998 and 1999 buyouts. The requested funding level for FY 1999 is an increase of $65.2 million from the FY 1998 budget plan of $2,033.8 million. Of this total increase, funding for Research and Operations Support increased $77.8 million. This increase reflects the continued high level of activity planned for the implementation of the Integrated Financial Management System (IFMS). Award of this contract was made late in Fiscal Year 1997, and will encompass six modules: Core Accounting: Budget: Executive information System: Travel; Procurement: and Time and Attendance. The overall implementation approach provides for a single contractor to work across all ten NASA centers to implement a single, integrated system. Centers will support the implementation contractor by providing guidance, data, and access to current systems. Funding to support the firm fixed price contract was included in Fiscal Year 1997 actuals. Center implementation activities are included in Fiscal Year 1998 estimates. The current schedule is as follows: Award of the contract was made in late FY 1997, delivery of all components at the Marshall Space Flight Center by October 1, 1998, and delivery at the remaining Centers phased over the next nine months. Funding for Travel increases slightly by $1.9 million in FY 99 to accommodate rapidly accelerating costs of travel both domestic and international associated with Space Station and other program initiatives across the agency.

Personnel and related costs decreases by $14.5 million due to a reduction of 845 FTE's from the expected FY 1998 level of 19,364 FTE. The savings of $61.5 million due to the FTE reduction is offset by $8.0 million for the full year cost of the FY 1998 pay raise, $24.0 million for the planned 2.5% payraise in FY 1999; and $15.0 million for the increased costs of health care, the increased share of government payments for retirement systems, and the costs of normal salary growth.

In summary, the FY 1999 budget requirement of $2,099,000,000 will provide for 18,519 FTE civil service workyears to support the activities at nine NASA Installations and Headquarters.

The following describes, in detail, the cost elements within this program.

I. Personnel and Related Costs

A. Compensation and Benefits

1. Compensation

a. Permanent Positions: This part of Personnel and Related Costs covers the salaries of the full-time permanent civil service workforce and is the largest portion of this functional category.

b. Other Than Full-Time Permanent Positions: This category includes the salaries of NASA's non-permanent workforce. Programs such as Presidential Management Interns, students participating in cooperative training, summer employment, youth opportunity, and temporary clerical support are covered in this category.

c. Reimbursable Detailees: In accordance with existing agreements, NASA reimburses the parent Federal organization for the salaries and related costs of persons detailed to NASA.

d. Overtime and Other Compensation: Overtime, holiday, post and night differential, and hazardous duty pay are included in this category. Also included are incentive awards for outstanding achievement and superior performance.

2. Benefits: In addition to compensation, NASA, as authorized and required by law, makes the employer's contribution to personnel benefits. These benefits include contributions to the Civil Service Retirement Fund, the Federal Employees Retirement System, employees' life and health insurance, payments to the Medicare

fund for permanent employees, and social security contributions. This budget includes the required additional 1.5%of salary agency contribution to the civil service retirement fund. Payments to the civil service retirement fund for re-employed annuitants and severance pay to former employees involuntarily separated through no fault of their own are also included.

B. Supporting Costs

1. Transfer of Personnel: Provided under this category are relocation costs required by law, such as the expenses of selling and buying a home, subsistence expenses, and the movement and storage of household goods.

2. Investigative Services: The Office of Personnel Management is reimbursed for activities such as security investigations of new hires and revalidation of sensitive position clearances, recruitment advertising, and Federal wage system surveys.

3. Personnel Training: Training is provided within the framework of the Government Employees Training Act of 1958. Part of the training costs are for courses offered by other Government agencies, and the remainder is for training through nongovernment sources.

II. Travel

A. Program Travel: The largest part of travel is for direction, coordination, and management of program activities including international programs and activities. The complexity of the programs and the geographical distribution of NASA Installations and contractors necessitate this category of travel. **As** projects reach the flight stage, support is required for prelaunch activities including overseas travel to launch and tracking sites. The amount of travel required for flight projects is significant as it is directly related to the number of systems and subsystems, the number of design reviews, and the number and complexity of the launches and associated ground operations.

€3. Scientific and Technical Development Travel: Travel to scientific and technical meetings and seminars permits employees engaged in research and development to participate in both Government sponsored and nongovernment sponsored activities. This participation allows personnel to benefit from exposure to technological advances which arise outside NASA, as well as allowing personnel to present both accomplishments and problems to their associates and provides for the dissemination of technical results to the United States community.

C. Management and Operations Travel: Management and operations travel provides for the direction and coordination of general management matters and travel by officials to review the status of programs. It also includes travel by functional managers in such areas as personnel, financial management, and procurement. This category also includes the cost of travel of unpaid members of research advisory committees: and initial duty station, permanent change of assignment, and related travel expenses.

III. Research Operations Support

A. Facilities Services: Facilities Services provides basic security, fire protection, and other custodial services. It also provides maintenance of roads and grounds and of all administrative buildings and facilities. Finally, it provides rental of administrative buildings and all utility costs of administrative buildings.

B. Technical Services: Technical Services provides the Administrative Automatic Data Processing capability that supports Accounting, Payroll, Budgeting, Procurement, and Personnel as well as all the other Administrative functions. It also funds the Graphics and Photographic support to these functions. Finally, it funds the Installation -wide safety and public information programs.

C. Management and Operations: Management and Operations funds the telephone, mail, and logistics systems, the administrative equipment and supplies, and the transportation system including the general purpose motor pools and the program support aircraft. It also funds the basic medical and environmental health programs. Finally, it funds printing and reproduction and all other support, such as small contract and purchases for the Center Directors staff and the Administrative functions.

SUMMARY OF BUDGET PLAN BY FUNCTION

	FY 1997	FY 1998 (Millions of Dollars)	FY 1999
I. Personnel and related	$1,588.4	$1,591.6	$1,577.1
II. Travel	$44.8	$45.5	$47.4
III. Research operations support	$445.3	$396.7	$474.5
Total	**$2,078.5**	**$2,033.8**	**$2,099.0**

DETAIL OF BUDGET PLAN BY FUNCTION

	FY 1997	FY 1998	FY 1999
		(Millions of Dollars)	
I. Personnel and related costs	**$1.588.4**	**$1.591.6**	**$1.577.1**
A. Compensation and benefits	$1.547.1	$1,550.0	$1,535.8
1. Compensation	$1,268.5	$1,271.0	$1,272.1
2. Benefits	$278.6	$279.0	$263.7
B. Supporting costs	$41.3	$41.6	$41.3
1. Transfer of personnel	$7.5	$7.7	$7.8
2. Investigative services	$3.3	$3.5	$3.7
3. Personnel training	$30.5	$30.4	$29.8
11. Travel	**$44.8**	**$45.5**	**$47.4**
A. Program travel	$31.0	$31.3	$32.7
B. Scientific and technical development travel	$4.1	$4.2	$4.3
C. Management and operations travel	$9.7	$10.0	$10.4
III. Research operations support	**$445.3**	**$396.7**	**$474.5**
A. Facilities services	$133.5	$126.0	$130.3
B. Technical services	$141.8	$144.2	$192.6
C. Management and operations	$170.0	126.5	$151.6
Total	**$2.078.5**	**$2.033.8**	**$2.099.0**

DISTRIBUTION OF BUDGET PLAN BY FUNCTION BY INSTALLATION
(MILLIONS OF DOLLARS)

FUNCTION	TOTAL NASA	JSC	KSC	MSFC	SSC	GSFC	ARC	DFRC	LARC	LERC	HQS
FY 1997	1,588.4	283.2	157.2	229.4	17.0	267.8	135.4	38.4	180.4	165.1	114.4
FY 1998	1,591.6	283.9	151.5	230.0	18.8	268.2	135.4	45.5	187.7	165.3	105.3
FY 1999	1.577.1	279.8	140.9	226.8	19.6	276.9	135.1	47.1	190.8	166.2	93.9
FY 1997	44.8	8.7	3.9	6.0	0.5	6.9	4.0	1.2	4.2	3.4	6.0
FY 1998	45.5	8.3	4.3	6.0	0.6	7.1	3.5	1.4	4.4	3.6	6.3
FY 1999	47.4	8.7	4.9	6.0	0.6	7.5	3.5	1.5	4.5	3.8	6.4
FY 1997	44.5.3	58.1	74.1	62.4	25.6	38.8	29.0	6.1	24.4	27.6	99.2
FY 1998	396.7	40.1	69.6	46.9	21.3	49.9	29.2	6.7	23.3	24.6	85.1
FY 1999	474.5	48.2	75.4	57.8	25.7	55.0	30.9	8.6	25.9	27.8	119.2
FY 1997	2,078.5	350.0	235.2	297.8	43.2	313.5	168.4	45.7	209.0	196.2	219.7
FY 1998	2,033.8	332.4	225.4	282.8	40.8	325.2	168.1	53.6	215.4	193.5	196.7
FY 1999	2,099.0	036.7	221.2	290.6	45.9	339.4	169.5	57.2	221.2	197.8	219.5

SUMMARY OF BUDGET PLAN BY INSTALJATION
(MILLIONS OF DOLLARS)

	FY 1997	FY 1998	FY 1999
JOHNSON SPACE CENTER	$350.0	$332.4	$336.7
KENNEDY SPACE CENTER	$235.2	$225.4	$221.2
MARSHALL SPACE FLIGHT CENTER	$297.8	$282.8	$290.6
STENNIS SPACE CENTER	$43.2	$40.8	$45.9
GODDARD SPACE FLIGHT CENTER	$313.5	$325.2	$339.4
AMES RESEARCH CENTER	$168.4	$168.1	$169.5
DRYDEN FLIGHT RESEARCH CENTER	$45.7	$53.6	$57.2
LANGLEY RESEARCH CENTER	$209.0	$215.4	$221.2
LEWIS RESEARCH CENTER	$196.2	$193.5	$197.8
HEADQUARTERS	$219.7	$196.7	$219.5
TOTAL	$2,078.5	$2,033.8	$2.099.0

DISTRIBUTION OF FULL-TIME EQUIVALENT(FTE) WORKYEARS BY INSTALLATION

	FY 1997	FY 1998	FY 1999
Johnson Space Center	3,174	3,048	2,796
Kennedy Space Center	1,955	1,805	1,701
Marshall Space Flight Center	2,923	2,782	2,670
Stennis Space Center	206	223	214
Ames Research Center	1,445	1,417	1,409
Dryden Flight Research Center	448	584	586
Langley Research Center	2,421	2,426	2,339
Lewis Research Center	2,108	2,022	1,947
Goddard Space Flight Center	3,370	3,300	3,235
Headquarters	1,142	1,067	965
Subtotal, full-time permanent workyears	**19,192**	**18,674**	**17,862**
Other Controlled FTEs	691	690	657
Total, full-time equivalents	**19.883**	**19.364**	**18.519**

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM

	FY 1997	FY 1998	FY 1999
Space station	1,852	2,157	2,233
U.S./Russian cooperative program	60	43	0
Space shuttle	2,435	2,344	2,196
Payload and utilization operations	750	457	310
Space science	2,157	1,951	1,832
Life and microgravity sciences	934	890	802
Earth Science	1,471	1,455	1,381
Aeronautics research and technology	3,373	3,374	3,283
Advanced space transportation technology	916	924	880
Commercial technology programs	254	237	227
Academic programs	64	65	64
Mission communication services	324	317	289
Space communications services	123	123	124
Safety, reliability and quality assurance	144	144	132
Construction of facilities	275	247	233
Subtotal, direct full-time permanent FTEs	**15,132**	**14,728**	**13,986**
Program management (Headquarters)	39	47	55
Center management and operations	4,021	3,899	3.821
Subtotal, full-time permanent FTEs	**19,192**	**18,674**	**17.862**
Other controlled FTEs	691	690	657
Total, full-time equivalents	**19.883**	**19.364**	**18.519**

LYNDON B. JOHNSON SPACE CENTER

ROLES AND MISSIONS

SPACE STATION - Development of the International Space Station will provide an on-orbit, habitable laboratory for science and research activities, including flight and test hardware and software, flight demonstrations for risk mitigation, ground operations capability and facility construction, shuttle hardware and integration for assembly and operation of the station, mission planning, and integration of Space Station systems.

Space Station elements will be provided by the U. S. and our international partners. The U. S. elements include two nodes, a laboratory module, truss segments, four photovoltaic arrays, a habitation module, three pressurized mating adapters, a cupola, unpressurized logistics carriers and a centrifuge accommodation module. Various systems are also being developed by the U. S. including thermal control, life support, navigation and propulsion, command and data handling, power systems, and internal audio/video. The U. S. elements also include the FGB energy tug, being provided by a Russian firm under the Boeing prime contract, and pressurized logistics modules, provided by Italy.

Canada, the European nations, Japan, and Russia are also developing hardware for the international Space Station program. Laboratory elements will be provided by the Japanese and European Space Agencies. Canada will provide the remote manipulator system, vital for assembly of the station. The Russian Space Agency is providing experiment, power, life support and service modules, Soyuz crew transfer vehicle, and universal docking modules.

The Johnson Space Center (JSC) has lead center management responsibility for the International Space Station program. In addition, specific JSC technical responsibilities include development of a set of facilities and systems to conduct the operations of the Space Station including on-orbit control of the Space Station.

The Center also provides institutional personnel as well as engineering and testbed support to the Space Station program. This includes test capabilities, the provision of Government Furnished Equipment (GFE), and engineering analysis support for the work of the prime contractor, its major subcontractors, and NASA system engineering and integration efforts.

U.S./RUSSIAN COOPERATIVE PROGRAM/AND RUSSIAN PROGRAM ASSURANCE - JSC will continue to conduct management of this program through completion in FY 1998.

SPACE SHUTTLE - JSC has lead center management responsibility for the Space Shuttle. In addition, JSC will provide development, integration, and operations support for the Mission Control Center (MCC), the Shuttle Mission Simulator

(SMS), and other ground facilities needed for Space Shuttle Operations. JSC will provide Space Shuttle operational flight program management including system integration, crew equipment modification and processing, crew training, flight mission planning and operations, and procurement of Orbiter hardware.

PAYLOAD AND UTILIZATION OPERATIONS - JSC will also conduct concept studies and development on flight systems and options for human transportation. JSC also provides support to Spacelab, the engineering and technical base, payload operations and support equipment, and technology program support. Under this program, the X-38 experimental vehicle is being developed to demonstrate the technologies and processes required to produce crew return vehicle.

SPACE SCIENCE - The Center will support the Agency's planetary science program in the area of geosciences required to support future programs, provide curatorial support for lunar materials, assist in information dissemination, and interact with outside scientists. This research focuses on the composition, structures, and evolutionary histories of the solid bodies of the universe.

LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS - JSC is the Lead Center for the following programs/functions; Biomedical Research and Countermeasures: Advanced Human Support Technologies: and Space Medicine. It also has a supporting role in the Microgravity Research program in biotechnology. As part of these activities, JSC will evaluate human physiological changes associated with the space flight environment and develop effective countermeasures to assure crew health and optimal performance during all phases of flight. It will define and develop on-board health care systems and environmental monitoring systems: crew medical training: ground-based medical support of missions: develop a longitudinal crew health data base; and develop medical and psychological crew selection criteria. The JSC has established a center for the support of biotechnology applications in Microgravity in order to study growth factors, medical chemo/immunotherapeutic, and human tissue transplantation. These activities have been consolidated into a biomedical science institute. The Center will integrate life science flight experiments for Spacelab; operate integrated payload systems; and train mission and payload specialists in the science aspect of their missions. In addition, the JSC will provide mission integration and operations functions for experiments flown on the NASA-Mir program, including Space Shuttle flights as well as those transported via Russian launch vehicle applications.

MISSION/SPACE COMMUNICATION SERVICES - The Space Operations Management Office (SOMO), manages the telecommunication, data processing, mission operation, and mission planning services needed to ensure the goals of NASA's exploration, science, and research and development programs are met in an integrated and cost-effective manner.

CENTER MANAGEMENT AND OPERATIONS - Provides management, administrative, and financial oversight of NASA programmatic elements under JSC cognizance. In addition, the center provides for the operation and maintenance of the institutional facilities, systems, and equipment.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM

JOHNSON SPACE CENTER

	FY 1997	FY 1998	FY 1999
Space station	1,034	1,208	1,186
U.S./Russian cooperative program	56	40	0
Space shuttle	1,150	1,076	1,029
Payload and utilization operations	240	116	0
Space science	44	28	25
Life and microgravity sciences	148	116	103
Earth Science	0	0	0
Aeronautics research and technology	0	0	0
Advanced space transportation technology	12	6	6
Commercial technology programs	23	23	19
Academic programs	9	6	5
Mission communication services	27	31	31
Space communications services	0	0	0
Safety, reliability and quality assurance	2	2	2
Construction of facilities	23	22	21
Subtotal, direct full-time permanent FTEs	**2,768**	**2,674**	**2,427**
Program management (Headquarters)	**0**	0	0
Center management and operations	406	374	369
Subtotal, full-time permanent FTEs	**3,174**	**3,048**	**2,796**
Other controlled FTEs	126	130	136
Total, full-time equivalents	**3,300**	**3.178**	**2.932**

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1999 ESTIMATES

JOHN F. KENNEDY SPACE CENTER

ROLES AND MISSIONS

SPACE STATION - The Kennedy Space Center (KSC) shares responsibility for operations capability and construction with the Johnson Space Center (JSC) to develop a set of facilities, systems, and capabilities to conduct the operations of the Space Station. KSC will develop launch site operations capabilities for conducting pre-launch and post-landing ground operations including integrated testing, interface verification, servicing, launch activities, and experiment-to rack physical integration. KSC will serve as the primary agent for management and integration of ground processes for all U S launched International Space Station elements from manufacture and assembly through verification and launch.

SPACE SHUTTLE - KSC will provide Space Shuttle launch preparation, including orbiter processing, and Ground Support Equipment (GSE) logistics; and operation and maintenance of GSE.

PAYLOAD AND UTILIZATION OPERATIONS - KSC serves as the Lead Center for all payload requirements at NASA. KSC will provide support for Spacelab assembly and checkout, payload experiment integration, upper stages processing, Spacelab and ground support equipment (GSE) logistics and operations and maintenance of GSE.

EXPENDABLE LAUNCH VEHICLES - KSC will provide government oversight of all launch vehicle and payload processing and checkout activities for all NASA contracted expendable launch vehicle and upper stage launch services both at KSC and the Vandenburg Air Force Base.

CENTER MANAGEMENT AND OPERATIONS - KSC will provide administrative and financial services in support of Center management and provide for the operation and maintenance of the institutional facilities, systems, and equipment.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM

KENNEDY SPACE CENTER

	FY 1997	FY 1998	FY 1999
Space station	250	360	353
U.S./Russian cooperative program	0	0	0
Space shuttle	779	791	736
Payload and utilization operations	334	175	161
Space science	42	33	27
Life and microgravity sciences	72	40	16
Earth Science	21	24	21
Aeronautics research and technology	0	0	0
Advanced space transportation technology	0	0	0
Commercial technology programs	21	21	21
Academic programs	1	1	1
Mission communication services	0	0	0
Space communications services	0	3	10
Safety, reliability and quality assurance	6	5	5
Construction of facilities	29	25	20
Subtotal, direct full-time permanent FTEs	**1,555**	**1,478**	**1,371**
Program management (Headquarters)	0	0	0
Center management and operations	400	327	330
Subtotal, full-time permanent FTEs	**1,955**	**1,805**	**1,701**
Other controlled FTEs	67	82	74
Total, full-time equivalents	**2,022**	**1.887**	**1.775**

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1999 ESTIMATES

GEORGE C. MARSHALL SPACE FLIGHT CENTER

ROLES AND MISSIONS

SPACE STATION - The Center will provide engineering support to the program including engineering analysis in support of the station system engineering and integration effort and the work of the prime and major subcontractors. Included also are the logistics carriers development and maintenance activities and the design integration of cargo elements for Station mission build and logistics supply flights. It will be responsible for developing payload utilization capabilities and planning and executing payload integration and operations activities. This includes the development and operation of the EXPRESS Rack and Pallet payload carriers, the payload operations integration center, and data systems.

SPACE SHUTTLE - As the Center of Excellence for establishing, upgrading, and maintaining world class excellence in space propulsion programs, MSFC will provide for the design, development, and procurement of propulsion elements for the space shuttle transportation system.

SPACE SCIENCE - MSFC will lead the development and operations of the Advanced X-ray Astrophysics Facility (AXAF) and the Relativity Mission (Gravity Probe-B) as well as management of selected payloads. As the Center of Excellence for Space Optics, MSFC will provide design and development effort.

LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS - As NASA's Lead Center for Microgravity Research, MSFC will manage and provide the fundamental science and technology for processing materials under conditions that allow detailed examination of the constraints imposed by gravitational forces. MSFC will perform research in the areas of crystal growth, fluid physics, biophysics, solidification mechanics, and polymeric materials. The Center will define and develop hardware apparatus for Microgravity research, and perform and manage research objectives, implementation, and applications to advance knowledge, improve the quality of life on Earth, and strengthen the foundations for continuing the exploration and development of space. Furthermore, emphasis will be given to developing and transitioning to the private sector the technology and applications of products developed for space.

AERONAUTICAL RESEARCH AND TECHNOLOGY - The Center will provide propulsion and vehicle technology to reduce cost and schedule risk in the development of next generation space transportation vehicles. It will develop technology in hybrid, liquid, other energy source propulsion systems, advanced manufacturing processes, and vehicle materials and structures. The Center will conduct technology efforts, under contract including cooperative agreements, with the U.S. launch vehicle industry, to improve the competitiveness of current systems.

EARTH SCIENCE - MSFC is studying the interrelationship of global-scale climate processes and regional-scale hydrology, which is the science of water's distribution and variability over Earth, its integrating role in linking the planet's physical, biogeochemical, and geophysical fluid subsystems, and the associated human dimensions of Earth system variability. Utilizing global observations and information systems, improved and validated predictive models will be developed. MSFC will also lead in the establishment and operation of the Global Hydrology and Climate Center

MISSION/SPACE COMMUNICATION SERVICES - MSFC manage and maintains the NASA Integrated Services Network (NISN) - NISN services provide communications hardware, software, and transmission medium that inter-connects NASA Headquarters, installations, universities, and major contractor locations for the transfer of data, voice, and video.

CENTER MANAGEMENT AND OPERATIONS - MSFC provides administrative and financial services in support of Center management and provides for the operation and maintenance of the institutional facilities, systems, and equipment. Lead center for the development and implementation of the NASA Automation Consolidation Center (NACC), Agency Consolidated Payroll, Earned Value Performance Management, and Agency Logistics Business Systems Operations and Maintenance.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
MARSHALL SPACE FLIGHT CENTER

	FY 1997	FY 1998	FY 1999
Space station	334	372	388
U.S./Russian cooperative program	0	0	0
Space shuttle	412	389	338
Payload and utilization operations	83	62	83
Space science	341	280	178
Life and microgravity sciences	362	354	398
Earth Science	86	68	70
Aeronautics research and technology	31	2	0
Advanced space transportation technology	561	558	540
Commercial technology programs	100	88	80
Academic programs	13	13	13
Mission communication services	0	0	0
Space communications services	13	13	13
Safety, reliability and quality assurance	18	20	18
Construction of facilities	28	27	20
Subtotal, direct full-time permanent FTEs	**2,382**	**2,246**	**2,139**
Program management (Headquarters)	**0**	0	*0*
Center management and operations	541	536	531
Subtotal, full-time permanent FTEs	**2,923**	**2,782**	**2,670**
Other controlled FTEs	40	55	55
Total, full-time equivalents	**2,963**	**2,837**	**2.725**

RSEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1999 ESTIMATES

JOHN C. STENNIS SPACE CENTER

ROLES AND MISSIONS

HUMAN SPACE FLIGHT - As the Lead Center for Propulsion Testing, SSC will operate, maintain, and manage a propulsion test center and related capabilities for development, certification, and acceptance of rocket propulsion systems and components. The Center will provide, maintain and manage the facilities and the related capabilities required for the continued development and acceptance testing of the Space Shuttle Main Engines. SSC will also maintain and support the Center's technical core laboratory and operations to enable SSC to conduct advanced propulsion test technology research and development for government and commercial propulsion programs.

EARTH SCIENCE - Through the Commercial Remote Sensing Program, SSC will enhance U.S. economic competitiveness via commercial partnership programs which apply remote sensing technologies in business applications and reduce new product development costs. As part of the Applied Research and Data Analysis program, SSC will conduct fundamental and applied research which increase our understanding of environmental systems sciences, with emphasis on coastal research of both land and oceans.

AERONAUTICAL RESEARCH AND TECHNOLOGY - Through the Technology Transfer and Small Business Innovative Research programs, SSC will broaden and accelerate the development of spin-off technologies derived from national investments in aerospace research. SSC will also support the development of new and innovative propulsion technologies through the Advanced Space Transportation Program which supports the agency goal of reducing the cost of access to space.

CENTER MANAGEMENT AND OPERATIONS - The Center will provide, operate, maintain, and manage the institutional base and laboratories required to accomplish and support assigned programs of NASA and other Federal and State agencies and organizations resident at the SSC.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
STENNIS SPACE CENTER

	FY 1997	FY 1998	FY 1999
Space station	0	0	0
U.S./Russian cooperative program	0	0	0
Space shuttle	40	35	35
Payload and utilization operations	21	21	15
Space science	0	0	0
Life and microgravity sciences	0	0	0
Earth Science	18	18	18
Aeronautics research and technology	0	0	0
Advanced space transportation technology	28	51	48
Commercial technology programs	4	4	4
Academic programs	4	4	4
Mission communication services	0	0	0
Space communications services	0	0	0
Safety, reliability and quality assurance	1	1	1
Construction of facilities	10	10	10
Subtotal, direct full-time permanent FTEs	**126**	**144**	**135**
Program management (Headquarters)	0	0	0
Center management and operations	80	79	79
Subtotal, full-time permanent FTEs	**206**	**223**	**214**
Other controlled FTEs	20	24	27
Total, full-time equivalents	**226**	**247**	**241**

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1999 ESTIMATES

AMES RESEARCH CENTER

ROLES AND MISSIONS

AERONAUTICAL RESEARCH AND TECHNOLOGY - Conduct aeronautics research in ground-based and airborne automation technologies, human factors and operational methodologies for efficient, safe and effective airspace operations. Develop an integrated set of experimental and computational technologies built around an embedded information systems backbone, to provide rapid, accurate vehicle synthesis and testing capabilities. Conduct research spanning computation through flight, for Rotorcraft and Powered Lift configurations and for high performance aircraft to improve efficiency, affordability, and performance. Continue an interdisciplinary research program which provides the technology base for the development of subsonic and high speed transport aircraft. Emphasize joint research and technology projects with other NASA installations, government agencies, industry and academia.

Strengthen basic research and technology development for aerospace systems that transport humans and instrumentation to and from space and within the atmospheres of other bodies within the solar system. Research is conducted on thermal protection systems and arcjet testing is performed to meet national needs for access to space and planetary exploration.

SPACE SCIENCE - Ames has the agency lead role in Astrobiology (the study of life in the universe) which in Space Science focuses on the origin of life and its possible development on other worlds. Research includes advanced laboratory and computation facilities for astrochemistry: planetary atmosphere modeling, including relationships to the atmosphere of the Earth: the formation of stars and planetary systems: and an infrared technology program to investigate the nature and evolution of astronomical systems. Development continues of the Stratospheric Observatory for Infrared Astronomy (SOFIA) for research to be conducted by various NASA/university teams. Research and development (R&D) in advanced information technologies are directed toward significantly increasing the efficiency of SOFIA as it becomes operational. Ames is also the lead center for information technology efforts in the cross-enterprise spacecraft technology program funded in space science.

LIFE AND MICROGRAVITY SCIENCES - Ames has the agency lead role in Astrobiology and Gravitational Biology and Ecology programs. These synergistic programs examine the adoption of life forms to reduce gravity and the evolution and distribution of life in the universe. Research continues into the effects of gravity on living systems using spaceflight experiments, ground simulation, and hypergravity facilities to understand the how gravity affects the development, structure and functions of living systems. *Also* studied are options for preventing problems in crew health and psychophysiology during and after extended spaceflight. Ames has a primary focus on advanced physical/chemical technologies for life support, including research into all aspects of regenerative life support. Research is conducted in the areas of ecosystems and health monitoring.

EARTH SCIENCE - Ames has the agency lead role in Astrobiology which in Earth Science focuses on the relationship between life on Earth and our changing environment. Instruments and computer models for the measurement and analysis of atmospheric constituents and properties from aircraft platform are being developed. Applied research and developments to enhance the use of remote and in-situ sensing technology for Earth resources applications continues.

SAFETY, RELIABILITY AND QUALITY ASSURANCE - Provide institutional safety and health programs and develop and integrate Safety, Reliability and Quality Assurance guidelines into program and project development.

CENTER MANAGEMENT AND OPERATIONS - Provide administrative and financial services in support of Center management and provides for the operation and maintenance of the institutional facilities, systems and equipment.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM: AMES RESEARCH CENTER

	FY 1997	FY 1998	FY 1999
Space station	41	44	54
U.S./Russian cooperative program	0	0	0
Space shuttle	0	0	1
Payload and utilization operations	1	1	0
Space science	185	183	186
Life and microgravity sciences	107	103	98
Earth Science	82	52	54
Aeronautics research and technology	652	641	637
Advanced space transportation technology	64	59	55
Commercial technology programs	12	12	12
Academic programs	9	9	9
Mission communication services	0	0	0
Space communications services	0	0	0
Safety, reliability and quality assurance	13	13	13
Construction of facilities	41	25	24
Subtotal, direct full-time permanent FTEs	**1,207**	**1,142**	**1,143**
Program management (Headquarters)	0	0	0
Center management and operations	238	275	266
Subtotal, full-time permanent FTEs	**1,445**	**1,417**	**1,409**
Other controlled FTEs	101	55	48
Total, full-time equivalents	**1,546**	**1,472**	**1,457**

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1999 ESTIMATES

DRYDEN FLIGHT RESEARCH CENTER

CENTER ROLES AND MISSIONS

AERONAUTICAL RESEARCH AND TECHNOLOGY - Develop, manage, and maintain facilities and testbed aircraft to support safe, timely, and cost effective NASA flight research and to support industry, university, and other government agency flight programs.

Conceive, formulate, and conduct piloted and unpiloted research programs in disciplinary technology, integrated aeronautical systems, and advanced concepts to meet current and future missions throughout subsonic, supersonic, and hypersonic flight regimes.

Conduct flight research prograrns in cooperation with other NASA Installations, other government agencies, the aerospace industry, and universities. Transition results, techniques, methods, and tools to industry and government users in a timely manner.

DFRC will also provide flight test support for atmospheric tests of experimental or developmental launch systems, including reusable systems.

SPACE SHUTTLE /PAYLOAD AND UTILIZATION OPERATIONS - The DFRC will provide operational and technical support for the conduct of Space Shuttle missions, including on-orbit tracking and communications, landing support of crew and science requirements.

CENTER MANAGEMENT AND OPERATIONS - Provide administrative services in support of Center management and provides for the operation and maintenance of the Institutional facilities, systems and equipment.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
DRYDEN FLIGHT RESEARCH CENTER

	FY 1997	FY 1998	FY 1999
Space station	0	0	0
U.S./Russian cooperative program	0	0	0
Space shuttle	29	29	29
Payload and utilization operations	0	0	0
Space science	0	0	0
Life and microgravity sciences	0	0	0
Earth Science	2	38	39
Aeronautics research and technology	224	315	314
Advanced space transportation technology	45	57	59
Commercial technology programs	3	3	3
Academic programs	0	0	0
Mission communication services	19	19	19
Space communications services	0	0	0
Safety, reliability and quality assurance	12	12	12
Construction of facilities	0	0	0
Subtotal, direct full-time permanent FTEs	**334**	**473**	**475**
Program management (Headquarters)	**0**	**0**	**0**
Center management and operations	114	111	111
Subtotal, full-time permanent FTEs	**448**	**584**	**586**
Other controlled FTEs	50	50	50
Total, full-time equivalents	**498**	**634**	**636**

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1999 ESTIMATE

LANGLEY RESEARCH CENTER

ROLES AND MISSIONS

AERONAUTICAL RESEARCH AND TECHNOLOGY - Conduct advanced research in fundamental aerodynamics: high-speed, highly maneuverable aircraft technology; hypersonic propulsion: guidance and controls: acoustics; and structures and materials. Develop a technology base for improving transport, fighter, general aviation, and commuter aircraft. Conduct an aeronautical research and technology program to study current and future technology requirements and to demonstrate technology applications. Conduct theoretical and experimental research in fluid and flight mechanics to determine aerodynamic flows and complex aircraft motions.

Develop innovative new airframe systems to improve safety and significantly reduce cost per seat mile of commercial transport aircraft and reduce emissions to improve environmental compatibility. Pioneer the development of new materials, structural concepts, and fabricate technologies to revolutionize the cost, performance, and safety of future aircraft structures for radically new aircraft design.

Study critical environmental compatibility issues in order to make decisions on future high speed civil transport technology and development programs. Develop technology options for realization of practical hypersonic and transatmospheric flight.

Conduct control and guidance research programs to advance technology in aircraft guidance and navigation, aircraft control systems, cockpit systems integration and interfacing techniques, and performance validation and verification methods, Conduct research in aircraft noise prediction and abatement.

Conduct aeronautics and space research and technology development for advanced aerospace transportation systems, including hypersonic aircraft, missiles, and space access vehicles using airbreathing and rocket propulsion. Specific technology discipline areas of expertise are aerodynamics, aerothermodynamics, structures, materials, hypersonic propulsion, guidance and controls, and systems analysis. Conduct long-range studies directed at defining the technology requirements for advanced transportation systems and missions.

EARTH SCIENCE - Perform an agency-designated Atmospheric Science mission role in support of the Earth Science Enterprise in the NASA Strategic Plan. Conduct a world-class peer reviewed and selected atmospheric science program in support of national goals in preserving the environment and in fundamental science. Specific discipline areas of expertise are Earth radiation research, particularly the role of clouds in the Earth's energy budget; middle and upper atmospheric research; and troposhperic research. Perform innovative scientific research to advance the knowledge of atmospheric radiative, chemical, and dynamic processes for understanding global change; develop innovative passive and active sensor systems concepts for atmospheric science measurements; explore advanced laser and LIDAR technologies for Earth science missions: develop advanced ultra-lightweight and adaptive materials, structural systems technologies and analytical tools for significantly reducing the end-to-end cost and increasing the performance of earth observation space instruments and systems. Serve as a Primary Data Analysis and Archival Center (DAAC) for Earth Radiation and Atmospheric Chemistry for the Earth Observing System.

SPACE SCIENCES -Support the solicitation and selection process of the Office of Space Science's (OSS) Discovery, Explorer and Solar Terrestrial Probes Programs: conduct reviews of candidate and selected missions and independent assessments of on-going space science missions to help ensure that OSS criteria for high quality science return within cost and schedule constrains are met: develop advanced ultra-lightweight and adaptive materials, structural systems technologies and analytical tools for significantly reducing the end-to-end cost and increasing the performance of space science instruments and systems. Langley is developing the SABER instrument which is on the TIMED mission to explore the mesosphere and lower thermosphere globally and achieve a major improvement in the understanding of the fundamental processes governing energetics, chemistry, dynamics and transport. Langley is also analyzing SAMPEX data to assess the relative importance of solar terrestrial coupling due to varying electron precipitation compared to that due to 11-year solar flux variations.

LIFE AND MICROGRAVITY SCIENCES - Conduct space radiation exposure studies in support of current and future human space efforts for a more accurate assessment of astronaut radiation exposures and body shielding factors.

SYSTEMS ANALYSIS/INDEPENDENT PROGRAM EVALUATION AND ASSESSMENT - Serve as the Agency lead center for systems analysis an the conduct of independent evaluation and assessment of Agency programs. Maintain, as a Center core competency, appropriate expertise and analysis tools to support the Agency's Strategic Enterprises in the definition and development of advanced systems concepts to achieve NASA's goals. Utilize core systems analysis capabilities (supplemented with expertise from other Centers as appropriate) to support the Office of the Administrator by conducting independent assessments of advanced concepts and proposed new systems to validate conceptual level designs prior to Agency commitment to major developmental funding. Support the Administrator's Program Management Council (PMC) in the organization, administration, and technical support of PMC review process.

SAFETY, RELIABILITY. AND QUALITY ASSURANCE - Provide a Safety, Reliability, and Quality Assurance program that conducts independent assessment activities which reduce program risk.

CENTER MANAGEMENT AND OPERATIONS - Provide administrative and financial services in support of Center management and provide for the operation and maintenance of the institutional facilities, systems, and equipment.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
LANGLEY RESEARCH CENTER

	FY 1997	FY 1998	FY 1999
Space station	24	11	8
U.S./Russian cooperative program	0	0	0
Space shuttle	4	6	6
Payload and utilization operations	12	25	0
Space science	81	86	78
Life and microgravity sciences	29	29	29
Earth Science	237	255	258
Aeronautics research and technology	1,456	1,405	1,354
Advanced space transportation technology	133	131	129
Commercial technology programs	33	33	33
Academic programs	0	0	0
Mission communication services	0	0	0
Space communications services	0	0	0
Safety, reliability and quality assurance	2	2	1
Construction of facilities	4	4	4
Subtotal, direct full-time permanent FTEs	**2,015**	**1,987**	**1,900**
Program management (Headquarters)	0	0	0
Center management and operations	406	439	439
Subtotal, full-time permanent FTEs	**2,421**	**2,426**	**2.339**
Other controlled FTEs	89	72	70
Total, full-time equivalents	**2,510**	**2,498**	**2.409**

RESEARCH AND **PROGRAM MANAGEMENT**

FISCAL YEAR 1999 ESTIMATES

LEWIS RESEARCH CENTER

ROLES AND **MISSIONS**

LIFE AND **MICROGRAVITY SCIENCES** - The Lewis Research Center (LeRC)provides leadership and management of the fluid physics, combustion science, acceleration measurement and telescience disciplines of NASA's Microgravity Science Program. Conducts and sponsors ground-based scientific studies that may lead to experiments in space. Lewis has a substantial effort in the design, buildup, testing, and integration of hardware for experiment packages to be launched aboard the Space Shuttle and the utilization of the Space Station for scientific missions.

SPACE STATION - LeRC support to the space station program includes technical and management support in the areas of power and on-board propulsion components and system, engineering and analysis, technical expertise, and testing for components and systems. This includes use of facilities and testbeds and construction of flight hardware as required.

MISSION COMMUNICATIONS SERVICES - LeRC manages and operates "next generation technology" communications satellite, to prove highrisk communication technologies, to transfer the knowledge gained to US satellite industry developers and users, and to reaffirm the US satellite communications preeminence in this rapidly growing world-wide market. The Center also ensures timely and high quality availability of radio frequency spectrum to enable the realization of NASA goals: actively stimulating the effective use of the Advanced Communications Technology Satellite (ACTS).

AERONAUTICAL RESEARCH AND **TECHNOLOGY** - As the NASA Lead Center for Aeropropulsion, LeRC conducts world-class research critical to the Agency Aeronautics Enterprise goals of developing and transferring enabling technologies to U.S. industry and other government agencies. The Center's Aeropropulsion program is essential to achieving National goals to promote economic growth and national security through safe, superior, and environmentally compatible U.S. civil and military aircraft propulsion systems. The Aeropropulsion Program spans subsonic, supersonic, hypersonic, general aviation, and high performance aircraft propulsion systems through innovative application of research in materials, structures, internal fluid mechanics, instrumentation and controls, interdisciplinary technologies, and aircraft icing.

As the NASA Center of Excellence in Turbomachinery, LeRC's expertise is critical to advancing the Agency's goals in the aeronautics and space programs. This designation enables LeRC to be a cost effective resource across multiple Agency programs in the vital and strategic discipline area of turbomachinery. Areas of expertise include air breathing propulsion and power systems, primary and auxiliary propulsion and power systems, on-board propulsion systems, and rotating machinery for the pumping of fuels.

CENTER MANAGEMENT AND **OPERATIONS** - Provides administrative and financial services in support of Center Management and provides for the operation and maintenance of the institutional facilities, systems, and equipment.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
LEWIS RESEARCH CENTER

	FY 1997	FY 1998	FY 1999
Space station	153	150	226
U.S./Russian cooperative program	0	0	0
Space shuttle	0	0	0
Payload and utilization operations	0	0	0
Space science	275	212	207
Life and microgravity sciences	169	207	125
Earth Science	33	33	10
Aeronautics research and technology	977	986	965
Advanced space transportation technology	55	46	30
Commercial technology programs	19	19	21
Academic programs	9	11	10
Mission communication services	44	44	46
Space communications services	12	13	6
Safety, reliability and quality assurance	23	25	21
Construction of facilities	0	0	0
Subtotal, direct full-time permanent FTEs	**1,769**	**1,746**	**1,667**
Program management (Headquarters)	**0**	**0**	**0**
Center management and operations	339	276	280
Subtotal, full-time permanent FTEs	**2,108**	**2,022**	**1,947**
Other controlled FTEs	67	77	76
Total, full-time equivalents	**2,175**	**2,099**	**2,023**

RESEARCH AND PROGRAM MANAGEMENT

FISCAL, YEAR 1999 ESTIMATES

GODDARD SPACE FLIGHT CENTER

ROLES AND MISSIONS

SPACE SHUTTLE/PAYLOAD AND UTILIZATION OPERATIONS - GSFC manages flights of the Hitchhiker, a reusable carrier system which provides increased flight opportunities with reduced lead-time while maximizing Space Shuttle load factors and minimizing spaceflight costs. GSFC also manages and coordinates the Agency's Get Away Special (GAS) program.

EXPENDABLE LAUNCH VEHICLES - Technical oversight for NASA payloads of the small and medium class ELVs, such as Pegasus and Delta, used to put a wide variety of spacecraft into a broad spectrum of orbits.

SPACE SCIENCE - GSFC manages physics and astronomy activities in the following discipline areas: gamma ray astronomy, X-ray astronomy, ultraviolet and optical astronomy, infrared and radio astronomy, particle astrophysics, solar physics, interplanetary physics, planetary magnetospheres, and astrochemistry. GSFC is also responsible for conducting the mission operations for a variety of operating spacecraft. Other activities include managing NASA's sounding rocket and scientific balloon program.

GSFC also conducts planetary exploration research into the physics of interplanetary and planetary space environments. Participates in planetary mission instrument development, operations, and data analysis. GSFC develops technologies targeted at improved spaceborne instruments, and on-board spacecraft systems and subsystems.

EARTH SCIENCE - Lead Center for Earth Science, including the Earth Observing System (EOS). The primary objective of the EOS is to record global change and to observe regional-to-global processes. The EOS will document global change over a fifteen year period to provide long-term, consistent data sets for use in modeling and understanding global processes. This process and modeling research effort will provide the basis for establishing predictive global change models for policy makers and scientists.

Manages Earth Probes and New Millennium flight projects; manages, on a reimbursable basis, the acquisition of meteorological observing spacecraft for the National Oceanic and Atmospheric Administration (NOAA). Conducts science correlation measurements from balloons, sounding rockets, aircraft, and ground installations.

AERONAUTICAL RESEARCH AND TECHNOLOGY - The Wallops Flight Facility conducts flight studies of new approach and landing procedures using the latest in guidance equipment and techniques, pilot information displays, human factors data, and terminal area navigation. As an integral partner in the Agency's High Performance Computing and Communications

(HPCC) program, GSFC leads an effort to enhance the infusion of HPCC technologies into the Earth and space science community through the provision of advanced computer architectures and communication technologies. Promotes private sector investment in space-based technologies through the transfer of technologies that derive from NASA's programs and activities.

MISSION/SPACE COMMUNICATION SERVICES - Research and technology involves the investigation and development of advanced systems and techniques for spacecraft communications and tracking, command and control, and data acquisition and processing. The primary objectives are to apply technology and develop advanced capabilities to meet the tracking and data processing requirements of new missions and to improve the cost effectiveness and reliability of flight mission support.

Although the Johnson Space Center is designated as the Space Operations Lead Center, GSFC manages a number of critical program elements, including operation of the Tracking and Data Relay Satellite System (TDRSS): the development of the replenishment TDRSS spacecraft: mission control, data processing, and orbit/attitude computation support: operating the Space Tracking and Data Network (STDN), the NASA Communications (NASCOM) Network, and the Aeronautics, Balloons and Sounding Rocket Program.

The NASCOM Network links the stations of the Deep Space Network (DSN), STDN, TDRSS, and other tracking and data acquisition elements with control centers and data processing and computation centers.

CENTER MANAGEMENT AND OPERATIONS - Provides administrative and financial services in support of Center management and provides for the operation and maintenance of the institutional facilities, systems, and equipment.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
GODDARD SPACE FLIGHT CENTER

	FY 1997	FY 1998	FY 1999
Space station	0	0	0
U.S./Russian cooperative program	0	0	0
Space shuttle	8	8	9
Payload and utilization operations	38	41	45
Space science	1,116	1,057	1,059
Life and microgravity sciences	0	0	0
Earth Science	968	943	887
Aeronautics research and technology	8	4	5
Advanced space transportation technology	5	5	5
Commercial technology programs	14	14	15
Academic programs	2	4	5
Mission communication services	211	208	193
Space communications services	94	90	95
Safety, reliability and quality assurance	20	19	16
Construction of facilities	122	117	117
Subtotal, direct full-time permanent FTEs	**2,606**	**2,510**	**2,451**
Program management (Headquarters)	0	0	0
Center management and operations	764	790	784
Subtotal, full-time permanent FTEs	**3,370**	**3,300**	**3,235**
Other controlled FTEs	83	120	111
Total, full-time equivalents	**3,453**	**3,420**	**3,346**

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1999 ESTIMATES

NASA HEADQUARTERS

ROLES AND MISSIONS

NASA Corporate Headquarters

MISSION - The mission of Headquarters is to plan and provide executive direction for the implementation of U. S. space exploration, space science, aeronautics, and technology programs. This includes corporate policy development, program formulation, resource allocations, program performance assessment, long-term institutional investments, and external advocacy for all of NASA.

MAJOR CORPORATE ROLES - At NASA Headquarters, the broad framework for program formulation will be conducted through four Strategic Enterprises: Human Exploration and Development of Space, Earth Science, Aeronautics and Space Transportation Technology, and Space Science. Consistent with the NASA strategic plan, the Strategic Enterprises develop program goals and objectives to meet the needs of external customers within the policy priorities of the Administration and Congress.

Corporate level enabling processes and staff functions will provide cross-cutting interfaces required to support the Strategic Enterprises in legislative affairs, public affairs, budget and financial management, equal opportunity programs, human resources, legal affairs, procurement, international affairs, management systems and facilities, information systems and technology, small business, safety and mission quality, advisory committees, and policy and plans.

The Office of Headquarters Operations provides and manages the infrastructure necessary to support the Headquarters installation.

PROGRAM MANAGEMENT - A cadre of personnel presently assigned to Headquarters provides program management for the NASA Management Office at Jet Propulsion Lab, communications stations in Spain and Australia, international representatives in France , Japan, and Moscow, and Intergovernmental Personnel Assignments/Detailees at various governmental, educational, and commercial organizations. This function reflects the operational components that logically report directly to Headquarters but who are not located on-site.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
NASA HEADQUARTERS

	FY 1997	FY 1998	FY 1999
Space station	16	12	18
U.S./Russian cooperative program	4	3	0
Space shuttle	13	10	13
Payload and utilization operations	21	16	6
Space science	73	72	72
Life and microgravity sciences	47	41	33
Earth Science	24	24	24
Aeronautics research and technology	25	21	8
Advanced space transportation technology	13	11	8
Commercial technology programs	25	20	19
Academic programs	17	17	17
Mission communication services	23	15	0
Space communications services	4	4	0
Safety, reliability and quality assurance	47	45	43
Construction of facilities	18	17	17
Subtotal, direct full-time permanent FTEs	**370**	**328**	**278**
Program management (Headquarters)	39	47	55
Headquarters management and operations	733	692	632
Subtotal, full-time permanent FTEs	**1,142**	**1,067**	**965**
Other controlled FTEs	48	25	10
Total, full-time equivalents	**1,190**	**1,092**	**975**

DETAIL OF PERMANENT POSITIONS

	FY 1997	FY 1998	FY 1999
Executive level II	1	1	1
Executive level IV	2	2	2
Subtotal	**3**	**3**	**3**
ES-6	55	50	50
ES-5	115	109	109
ES-4	180	167	167
ES-3	70	70	70
ES-2	66	62	62
ES-1	50	47	47
Subtotal	**536**	**505**	**505**
CA	1	1	1
SL/ST	59	57	55
GS/GM-15	2250	2140	2050
GS/GM-14	3444	3274	3137
GS/GM-13	6335	6025	5773
GS-12	2032	1932	1852
GS-11	1278	1216	1165
GS-10	275	261	250
GS-09	447	425	408
GS-08	223	212	203
GS-07	678	645	618
GS-06	548	522	500
GS-05	238	226	217
GS-04	19	18	17
GS-03	3	3	3
GS-02	1	1	1
Subtotal	**17,831**	**16,958**	**16,250**
Special ungraded positions established by NASA Administrator	25	25	25
Ungraded positions	394	394	394
Total permanent positions	**18,789**	**17,885**	**17,177**
Unfilled positions, EOY	0	0	0
Total, permanent employment, EOY	**18,789**	**17,885**	**17,177**

PERSONNEL SUMMARY

	ET 1997	FY 1998	ET 1999
Average GS/GM grade	12.4	12.4	12.4
Average ES salary	$116,828	$119,450	$122,129
Average GS/GM salary	$59,844	$61,161	$62,506
Average salary of special ungraded positions established by NASA Administrator	$90,604	$92,597	$94,634
Average salary of ungraded positions	$43,319	$44,272	$45,246

CENTER LOCATIONS AND CAPITAL INVESTMENT

JOHNSON SPACE CENTER - The Lyndon B. Johnson Space Center is located 20 miles southeast of Houston, Texas. NASA owns 1,618 acres of land at the Houston site and uses another 60,552 at the White Sands Test Facility, Las Cruces, New Mexico. The total replacement cost including land, buildings, structures and facilities, equipment, and other fixed assets was $2,838,867,000 as of September 30, 1997.

KENNEDY SPACE CENTER - The Kennedy Space Center is located 50 miles east of Orlando, Florida. NASA owns 82,943 acres and uses launch facilities at Cape Canaveral Air Station and Vandenberg Air Force Base. The total replacement cost including land, buildings, structures and facilities, equipment, and other fixed assets was $1,756,472,000 as of September 30, 1997.

MARSHALL SPACE FLIGHT CENTER - The Marshall Space Flight Center is located within the U.S. Army's Redstone Arsenal at Huntsville, Alabama. MSFC also manages operation at the Michoud Assembly 15 miles east of New Orleans, Louisiana and the Slidell Computer Complex in Slidell, Louisiana. The total replacement cost including land, buildings, structures and facilities, equipment, and other fixed assets was $3,245,500,000 as of September 30, 1997.

STENNIS SPACE CENTER - The Stennis Space Center is located approximately 50 miles northeast of New Orleans, Louisiana. NASA owns 20,663 acres and has easements covering an additional 118,284 acres. The total replacement cost including land, buildings, structures and facilities, equipment, and other fixed assets was $551,874,000 as of September 30, 1997.

AMES RESEARCH CENTER - The Ames Research Center is located south of San Francisco on Moffett Field, California. NASA owns 447.5 acres at the Moffett Field location. The total replacement cost including land, buildings, structures and facilities, equipment, and other fixed assets was $1,269,040,000 as of September 30, 1997.

DRYDEN FLIGHT RESEARCH CENTER - The Dryden Flight Research Center is 65 air miles northeast of Los Angeles. Dryden is located at the north end of Edwards Air Force Base on 838 acres of land under a permit from the Air Force. The total replacement cost at Dryden, including fixed assets in progress and contractor-held facilities at various locations, as of September 30, 1997 was $393,126,000.

LANGLEY RESEARCH CENTER - The Langley Research Center is adjacent to Langley Air Force Base which is located between Williamsburg and Norfolk at Hampton, Virginia. NASA owns 788 acres and has access to 3,276 acres. The total replacement cost including land, buildings, structures and facilities, equipment, and other fixed assets was $1,409,449,000 as of September 30, 1997.

LEWIS RESEARCH CENTER - The Lewis Research Center occupies two sites; the main site is in Cleveland, Ohio, adjacent to Cleveland-Hopkins Airport: the second site is the Plum Brook Station located south of Sandusky, Ohio, and 50 miles west of Cleveland. NASA owns 6,805 acres and leases an additional 14 acres at the Cleveland location. The total replacement cost including land, buildings, structures and facilities, equipment, and other futed assets at both locations was $872,415,000 as September 30, 1997.

GODDARD SPACE FLIGHT CENTER - The Goddard Space Flight Center is located 15 miles northeast of Washington, D.C. at Greenbelt, Maryland. NASA owns 1,121 acres at this location and an additional 6,176 acres at the Wallops Flight Facility in Wallops Island, Virginia. The total replacement cost including land, buildings, structures and facilities, equipment, and other fixed assets $2,471,477,000 as of September 30, 1997.

NASA HEADQUARTERS - NASA Headquarters is located at Two Independence Square, 300 E St. SW, Washington, D.C. and occupies other buildings in the District of Columbia, Maryland, and Virginia.

Construction of Facilities

MISSION SUPPORT

FISCAL YEAR 1999 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANAGEMENT SYSTEMS AND FACILITIES — **CONSTRUCTION OF FACILITIES**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999	Page Number
	(Thousands of Dollars)			
Human Space Flight Appropriation..................................	8,300	6,800	7,600	MS 4-7
Science, Aeronautics and Technology Appropriation...........	2,300	5,900	5,600	MS 4-17
*Mission Support Appropriation	155.300	122,400	165,000	MS 4-20
Total..	165,900	135.100	178.200	

*See page 4-21 for center distribution.

PROGRAM GOALS

The goal of the Construction of Facilities program is to ensure that the facilities critical to achieving NASA's space and aeronautics program are functioning effectively, efficiently, and safely.

STRATEGY FOR ACHIEVING GOALS

The Construction of Facilities budget line item in the Mission Support appropriation provides for Discrete projects required for components of the basic infrastructure and institutional facilities. The Mission Support appropriation also includes Minor Revitalization projects (repair, rehabilitation, modernization, and modification of existing facilities), Minor Construction projects, Environmental Compliance and Restoration activities, the design of facilities projects, and advanced planning related to future facilities needs. The FY 1998 CoF Budget has been reduced $12 million, reflecting the Agency's proposed transfer of funds for Space Station use. Funding for Discrete projects required to conduct specific Human Space Flight or Science, Aeronautics, and Technology programs or projects are included in their own appropriations. Narrative descriptions and justifications for all construction projects are included in Mission Support to identify the total facilities required in FY 1999.

The Human Space Flight FY 1999 budget request provides Discrete projects for refurbishment of the Pad A flame deflector and trench and the Fixed Support Structure Elevator System at Kennedy Space Center, and repairs to Cleaning Cell E in the Vertical Assembly Building and rehabilitation of the 480 volt electrical distribution system in the External Tank Manufacturing Building at the Michoud Assembly Facility. No projects are included within the Science, Aeronautics and Technology appropriation for the FY 1999 budget. In Mission Support, funding is requested in FY 1999 for Discrete projects to repair and modernize utility and building systems which have reached or exceeded their normal design life. These systems include mechanical, structural, cooling, steam, and electrical distribution at Ames Research Center, Goddard Space Flight Center, Johnson Space Center, Kennedy Space Center, Langley Research Center, Lewis Research Center and Marshall Space Flight Center. *Also* included is a project at the Jet Propulsion Laboratory to construct a facility to consolidate the R&D facilities required for development and test of electronic In-Situ instruments; they are currently housed in various substandard facilities, which will be planned for demolition.

NASA facilities are critical to the development and operation of the space transportation system. They are necessary to sustain payloads and launch operations, as well as our aeronautical and aerospace testing capabilities, that also support military and private industry users.

The FY 1999 construction projects help preserve and enhance the capabilities and usefulness of existing facilities and ensure the safe, economical, and efficient use of the NASA physical plant. The Minor Revitalization program included in this request continues the necessary rehabilitation, modification, and repair of facilities. The Minor Construction program provides a means to accomplish smaller facility projects which accommodate changes in technical and institutional requirements that require additional facility capability or space.

Funds requested for Facility Planning and Design cover advance planning and design requirements for potential future projects, preparation of facility project design drawings and bid specifications, master planning, facilities studies, and engineering reports and studies. *Also* included are critical functional leadership activities directed at increasing the rate of return of constrained Agency resources while keeping the facility infrastructure safe, reliable, and available.

The Environmental Compliance and Restoration program (ECR) is critical to ensuring that statutory and regulatory environmental requirements and standards are met and that necessary remedial actions are promptly taken.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

SUMARY OF BUDGET PLAN BY APPROPRIATION AND PROJECT

INSTALLATION AND PROJECT	FY 1997	FY 1998	FY 1999	Page Number
		(Thousands of Dollars)		
HUMAN SPACE FLIGHT	8,300	6,800	7,600	
Refurbish Pad A Fixed Support Structure Elevator System (KSC)	---	---	2,300	MS 4-8
Refurbish Pad A Flame Deflector and Trench (KSC)	---	---	1,500	MS4-10
Rehabilitation of 480V Electrical Distribution System, External Tank Manufacturing Building (MAF)	2,500	2,800	2,000	MS 4-12
Repairs to Cleaning Cell E, Vertical Assembly Building (MAF)	---	---	1,800	MS4-15
Repair of Payload Changeout Room Wall & Ceiling, Pad A (KSC)	---	2,200	---	
Restoration of Pad Surface & Slope, Pad A (KSC)	---	1,800	---	
Replacement of LC-39 Pad B Chillers (KSC)	1,800	---	---	
Restoration of Pad B Fixed Support Structure Elevator System (KSC)	1,500	---	---	
Restoration **of** High Pressure Industrial Water Plant (SSC)	2,500	---	---	
SCIENCE, AERONAUTICS, AND TECHNOLOGY	2.300	5,900	5,600	
SPACE SCIENCE				
Modification of Stratospheric Observatory for Infrared Astronomy (SOFIA) Ground Support Facility	---	---	5,600	MS4-17
LIFE AND MICROGRAVITY SCIENCE AND APPLICATIONS				
Modifications for the Installation of the Bio-Plex (JSC)	---	2,200	---	
AERONAUTICS AND SPACE TRANSPORTATION TECHNOLOGY				
Rehabilitation and Modification of Test StandS (SSC)	2,300	3,700	---	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

SUMARY OF BUDGET PLAN BY APPROPRIATION AND PROJECT

INSTALLATION AND PROJECT	FY 1997	FY 1998	FY 1999	Page Number
		(Thousands of Dollars)		
MISSION SUPPORT				
Modernization of Process Cooling System, Numerical Aerodynamic Simulation Facility (ARC)	---	---	2,700	MS 4-22
Restoration of Electrical Distribution System (ARC)	2,400	---	2,200	MS 4-25
Restoration of Site Steam Distribution System (GSFC)	---	---	2,000	MS 4-28
Restoration of Space/Terrestrial Application Facility (GSFC)	---	---	5,000	MS 4-30
Construction of In-Situ Instruments Laboratory (JPL)	---	---	5,000	MS 4-32
Replacement of Central Plant Chilled Water Equipment (JSC)	---	---	3,000	MS 4-35
Replacement of High Voltage Load Break Switches (KSC)	---	---	2,200	MS 4-37
Upgrade of Utility Annex Chilled Water Plant (KSC)	---	4,000	1,900	MS 4-39
Rehabilitation of Instrument Research Laboratory (LARC)	---	---	3,100	MS 4-41
Rehabilitation of High Voltage System (LeRC)	---	9,000	8,300	MS 4-44
Modification of Chilled Water System (MSFC)	6,700	6,700	7,200	MS 4-46
Rehabilitation and Modification of Hangar/Shop (DFRC)	---	2,700	---	
Restoration of Chilled Water Distribution System (GSFC)	4,000	2,171	---	
Construction of Emergency Services Facility (JPL)	---	4,600	---	
Construction of Addition to Administration Building (SSC)	---	5,000	---	
Modification of Aircraft Ramp and Tow Way (DFRC)	3,000	---	---	
Restoration of Hangar Building 4801 (DFRC)	4,500	---	---	
Modernization of Secondary Electrical Systems (GSFC)	1,500	---	---	
Modification of Refrigeration Systems, Various Buildings (JPL)	2,800	---	---	
Rehabilitation of Electrical Distribution System, White Sands Test Facility (JSC)	2,600	---	---	
Rehabilitation of Utility Tunnel Structure and Systems (JSC)	4,400	---	---	
Replacement of DX Units with Central Chilled Water System, Logistics Facility, (KSC)	1,800	---	---	
Rehabilitation of Central Air Equipment Building (LeRC)	6,500	---	---	
Rehabilitation of Condenser Water Svstem, 202/207 Complex (MAF)	2,100	---	---	
Total Mission Support Discrete Projects	42,300	34,171	42,600	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

SUMARY OF BUDGET PLAN BY APPROPRIATION AND PROJECT

INSTALLATION AND PROJECT	FY 1997	FY 1998	FY 1999	Page Number
		(Thousands of Dollars)		
MISSION SUPPORT (continued)				
Minor Revitalization of Facilities at Various Locations, Not in excess of $1,500,000 per project	57,900	56,729	68,400	MS 4-49
Minor Construction of New Facilities and Additions to Existing Facilities at Various Locations, Not in excess of $1,500,000 per project	3,400	1,100	---	
Facility Planning and Design	18,700	19,000	14,000	MS 4-55
Environmental Compliance and Restoration	33.000	11,400	40,000	MS 4-59
Total - Mission Support	155,300	122.400	165.000	

RECORDED VALUE OF CAPITAL TYPE PROPERTY
IN-HOUSE AND CONTRACTOR-HELD
AS OF SEPTEMBER SO. 1997
(DOLLARS IN THOUSANDS)

REPORTING INSTALLATION	LAND	BUILDING	OTHER STRUCTURES AND FACILITIES	LEASEHOLD IMPROVEMENTS	TOTAL	EQUIPMENT	FIXED ASSETS IN PROGRESS	GRAND TOTAL
AMES RESEARCH CENTER	6.865	709,871	69.667	0	786.403	348,899	133.738	1,269.040
ARC MOFFETT FIELD, CA	2.928	654,642	30.181	0	687,751	348,899	133.738	1,170.388
DRYDEN FLIGHT FACILITY EDWARDS. CA	0	0	0	0	0	0	0	0
VARIOUS LOCATIONS	3.937	55,229	39,486	0	98.652	0	0	98.652
GODDARD SPACE FLIGHT CENTER	3.351	348.747	172.398	0	524,496	830.380	1,116.601	2,471.477
GSFC-GREENBELT. MD	1,577	244.570	56.291	0	302,438	432,577	99,756	834,771
TRACKING STATIONS NETWORK	0	39,406	11,419	0	50,825	225.812	0	276.637
WFF-WALLOPS ISLAND, VA	1.774	59,025	96.007	0	156.806	79.905	0	236.711
VARIOUS LOCATIONS	0	5,746	8.681	0	14,427	92.086	1,016,845	1,123,358
JET PROPULSION LABORATORY	1,189	242.480	157,592	666	401.927	378,251	1,870,596	2,650,774
JPL PASADENA, CA	1.189	242.480	157.592	666	401.927	378.251	1,870,596	2,650,774
JOHNSON SPACE CENTER	12,450	417,183	151,495	154	581,282	1,394,617	862,968	2,838,867
JSC-HOUSTON. TX	8.503	343.419	105.081	0	457,003	474,740	20,405	952,148
WHITE SANDS TEST FACILITY LOS CRUCE!	377	21,090	40.372	I54	61.993	0	0	61,993
VARIOUS LOCATIONS	3.570	52,674	6.042	0	62.286	919,877	842.563	1,824,726
KENNEDY SPACE CENTER	73.672	735,445	628.015	0	1,437,132	236.272	83.068	1,756,472
KSC-CAPE CANAVERAL. FL	73.672	735.445	628.015	0	1,437,132	97.932	81,785	1.616,849
WESTERN TEST RANGE, LOMPOC. CA	0	0	0	0	0	3.671	0	3.671
VARIOUS LOCATIONS	0	0	0	0	0	134.669	1,283	135,952
LANGLEY RESEARCH CENTER	156	275,852	465.561	0	741.569	373.152	294.728	1,409,449
LARC-HAMPTON, VA	156	275.852	465,561	0	741.569	349.494	67.008	1,158,071
VARIOUS LOCATIONS	0	0	0	0	0	23,658	227.720	251.378
LEWIS RESEARCH CENTER	2.621	353,262	124.695	136	480.714	273,239	118,462	872,415
LERC-CLEVELAND. OH	316	273,328	102.511	136	376,291	179.122	92,953	648.366
PLUM BROOK. SANDUSKY. OH	2.305	79.934	22,184	0	104,423	79.603	0	184,116
VARIOUS LOCATIONS	0	0	0	0	0	14,424	25,509	39,933
MARSHALL SPACE FLIGHT CENTER	7.162	412,990	209.754	0	629.906	772.503	1,843,091	3,245,500
MSFC-HUNTSVILLE, AL	0	231.137	103.674	0	334.811	571,565	1,843,091	2,749,467
MICHOUD ASSEMBLY FACILITY, LA	7.162	177.025	95,774	0	279.961	76.859	0	356.820
SLIDELL COMPUTER COMPLEX, LA	0	0	0	0	0	0	0	0
VARIOUS LOCATIONS	0	4.828	10.306	0	15.134	124,079	0	139.213
STENNIS SPACE CENTER	18,080	141,583	265.701	0	425.364	58.890	67,620	551.874
STENNIS SPACE CENTER	18.080	141,583	265.551	0	425.214	58,890	67,620	551,724
VARIOUS LOCATIONS	0	0	150	0	150	0	0	150
NASA HEADQUARTERS	0	0	0	0	0	41,626	44.687	86.313
NASA-HQS. WASH, DC	0	0	0	0	0	41,626	44.687	86.313
VARIOUS LOCATIONS	0	0	0	0	0	0	0	0
DRYDEN FLIGHT RESEARCH CENTER	0	73,806	33.979	0	107,785	279.609	5,732	393.126
DRYDEN FLIGHT FACILITY EDWARDS. CA	0	73.806	33.979	0	107,785	279.002	5,732	392.519
VARIOUS LOCATIONS	0	0	0	0	0	607	0	607
AGENCY TOTAL	125,546	3,711,219	2,278,857	956	6.116.578	4,987,438	6.441,291	17,545,307

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1999 ESTIMATES

SUMMARY

HUMAN SPACE FLIGHT

	Amount (Dollars)	Page No
Other Human Space Flight:		
Reburbish Pad A Fixed Support Structure Elevator System (KSC)	2,300,000	MS 4-8
Reburbish Pad A Flame Deflectors and Trenches (KSC)	1,500,000	MS 4-10
Rehabilitation of 480V Electrical Distribution System, External Tank Manufacturing Building (MAF)	2,000,000	MS 4-12
Repairs to Cleaning Cell E, Vertical Assembly Building (MAF)	1,800,000	MS 4-15
Total Human Space Flight	7,600,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

PROJECT TITLE: Refurbish Pad A Fixed Support Structure Elevator System

INSTALLATION: Kennedy Space Center

FY 1999 Estimate: $2,300,000

LOCATION OF PROJECT: Cape Canaveral, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1998 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding	$128,000	---	$ 128,000
Capitalized Investment	---	$100,073,984	100,073,984
Total	$128.000	$100.073.984	$100.201.984

SUMMARY PURPOSE AND SCOPE:

This project refurbishes the Pad A fixed support structure (FSS) elevator system. The elevator system has corroded structural components as well as obsolete and unreliable motors and controls. The elevator system directly supports launch operations, and must be maintained to a high level of operating reliability.

PROJECT JUSTIFICATION:

The elevator hoist-way structure is corroded and in need of refurbishment. Continuous soaking from launch residue and wash-down water has deteriorated the structural components and the elevator cab. The elevator motors are over 30 years old and do not reliably operate and urgently need to be refurbished or replaced.

IMPACT OF DELAY:

Pad A is scheduled to be closed for repairs beginning in early 1999. Refurbishing the elevator at the same time will make full use of the pad closure and prevent future closures that would occur if the elevator system fails. Delaying this project will lead to continued deterioration in service and support of the Pad A FSS elevator for critical operations, an increase in maintenance costs, and extended down time delays.

PROJECT DESCRIPTION:

The refurbishment of the Pad A FSS elevator includes refurbishment of cabs, rails, and floor beams; replacement of hoist-way structural components; redesign of connections, beams, and shaft enclosure; elimination of wash-down system; and replacement or refurbishment of elevator hoist motors.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Elevator refurbishment	Lump Sum (LS)	1	---	$2,300,000
Total				$2,300,000

OTHER EQUIPMENT SUMMARY: None.

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: None.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

PROJECT TITLE: Refurbish Pad A Flame Deflectors and Trenches

INSTALLATION: Kennedv Space Center

FY 1999 Estimate: $1,500.000

LOCATION OF PROJECT Cape Canaveral, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1998 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding	$150,000	---	$ 150,000
Capitalized Investment	---	$100,073,984	100,073,984
Total	$150,000	$100,073,984	$100,223,984

SUMMARY PURPOSE AND SCOPE:

This project replaces the corroded Solid Rocket Booster (SRB) and Space Shuttle Main Engine (SSME)flame deflectors at Launch Complex 39, Pad A. The existing “protective”coating and support steel will be replaced with a new-design staggered stud attachment. Repairs to the flame trenches walls and floor will also be made.

PROJECT JUSTIFICATION:

The flame and heat protective coating on the SRB and SSME flame deflectors is fracturing from the launch environment, and large sections are breaking out. Structural steel supporting the deflectors near the flame trench floor is corroding to the point of failure and causing deformation of the coating support plate. Sections of the flame trench liner bricks are breaking loose. Replacements for these bricks are no longer available.

IMPACT OF DELAY:

Launch Pad A is scheduled to be closed for repairs beginning in early FY99. Performing the flame deflector repairs at the same time will make full use of the pad closure and prevent future closures that may occur if a catastrophic failure of the flame deflectors or steel supports occurs. Delaying the project will require continued spot repairs which are becoming more frequent and having diminished effectiveness. Permanent repairs are also required to reduce the risk of foreign object damage to the Space Shuttle from loose debris and to prevent further "bum through" of unprotected coating plates.

PROJECT DESCFUFTION:

This project will replace the SRB and SSME main flame deflectors at LC-39 Pad A and repair the flame trenches walls and floors.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
SSME Deflector	LS	---	---	$ 500,000
SRB Deflector	LS	---	---	700,000
Steel Support	LS	---	---	**300,000**
Total				$1,500,000

OTHER EQUIPMENT SUMMARY: None

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

PROJECT TITLE: Rehabilitation of 480V Electrical Distribution System, External Tank Manufacturing Building

INSTALLATION: Michoud Assemblv Facilitv

FY 1999 ESTIMATE: $2,000,000

LOCATION OF PROJECT: New Orleans, Orleans Parish, Louisiana

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1998 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding	$512,000	$ 5,300,000	$ 5,812,000
Capitalized Investment	---	53,552,791	53,552,791
Total	$512,000	$58,852,791	$59,364,791

SUMMARY PURPOSE AND SCOPE:

This project rehabilitates and modifies the 480V electrical distribution system which supports critical External Tank (ET) manufacturing operations in the Machine Shop, Heat Treatment Facility, and Chemical Clean Line areas of the ET Manufacturing Building (103). This project specifically replaces the electrical distribution system associated with substations 17A and 17B. It is required to restore quality and reliability to the electrical power system and avoid costly piecemeal repairs. Building 103 is required for the Michoud Assembly Facility to perform its assigned Agency roles and missions.

PROJECT JUSTIFICATION:

The 480V electrical distribution system in Building 103 was originally installed in the 1940's. Exposed distribution feeders resulting from cracked insulation and "spot" overloads combine to create the forced outages and unacceptable potential production shutdowns. Existing bus ducts are inaccessible for maintenance due to crowded configuration of overhead utility corridors. Feeder taps to fan houses lack overcurrent protection. Main distribution and sub-distribution panels and associated breakers are obsolete. Existing grounding no longer meets the National Electric Code (NEC) nor current design standards. An in-house long range electrical plan and a subsequent A/E study recommend upgrade of the 480V power distribution system. This project is needed to provide a safe and reliable 480V electrical distribution system from substations 17A and 17B to the Machine Shop, Heat Treatment Facility, and Chemical Clean Line areas of Building 103. It also supports the mechanical equipment room for the ET welders. This project continues the systematic rehabilitation of older high-voltage systems in critical production areas.

IMPACT OF DELAY:

Failure to rehabilitate exposed feeders, hot spots, and improper grounding may likely result in unacceptable production shutdowns in the Machine Shop, Heat Treatment Facility, and Chemical Clean Line areas of the External Tank manufacturing operations.

PROJECT DESCRIPTION:

This project replaces transformers and switch gear; breakers and oil switches; and installs new main distribution and sub-distribution power panels. New electrical distribution feeders will be routed in cable trays for ease of maintenance. Electrical distribution circuits will be designed to eliminate the need for bus ducts. The new distribution system will be tied into substation switch gear and the old distribution system will be demolished.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Electrical	LS	---	---	$2,000,000
Total				$2,000,000

OTHER EQUIPMENT SUMMARY: None

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: None. However, future CoF funding in the amount of $1,800,000 will be required in FY 2000 to rehabilitate the 480V electrical distribution system in the remaining areas of Building 103.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

PROJECT TITLE: Repairs to Cleaning Cell "E", Vertical Assemblv Building

INSTALLATION: Michoud Assembly Facilitv

FY 1999 Estimate: $1.800.000

LOCATION OF PROJECT: New Orleans, Orleans Parish, Louisiana

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1998 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding	$144,000	---	$ 144,000
Capitalized Investment	---	$22,907,105	22,907,105
Total	$144.000	$22,907,105	$23.051,105

SUMMARY PURPOSE AND SCOPE:

This project provides for repairs to Cleaning Cell "E" necessary to improve maintainability and restore reliability of critical external tank manufacturing operations in the Vertical Assembly Building (110). This project replaces and relocates the common solution return pump, replaces the liner in the upper one-third of the cell, and repairs the lower two-thirds of the topcoat liner.

PROJECT JUSTIFICATION:

The common solution pump is located in the Cell E pit and is submerged during normal Cell E External Tank wash operations. The pump frequently fails during the wash cycle, resulting in adverse production schedule impacts, repeat washing, and quality concerns. *Also,* the main pump cannot be accessed for repair if a liquid oxygen tank is present in the cell, thus consuming additional manpower to relocate the liquid oxygen tank while repairs are performed on the system.

Cell E was constructed in 1978 for the internal and external LO2 Tank cleaning, and internal LH2 Tank cleaning. Since the original construction, the corrosive fluid used in the process has eroded the three-layer coating which protects the concrete interior surface of the cell. The upper one-third has never been comprehensively repaired, the lower two-thirds was repaired in 1987.

IMPACT OF DELAY:

Current configuration presents a single-point failure of the common solution return system and has the potential for total External Tank production shutdown in Cell E. Moving the pump outside of the cell and providing redundancy will mitigate impact to Cell E operations.

PROJECT DESCRIPTION:

This project constructs a concrete sump outside of the cell pit: installs two variable-speed vertical centrifugal pumps; and replaces associated piping, doors, control valves, instrumentation, electrical power, and lighting. In addition, this project repairs the upper one-third of the cell liner to bare concrete, and repairs the topcoat of the lower two-thirds of the liner.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Electrical	Lot	1	---	$150,000
Mechanical	Lot	1	---	750,000
Structural	Lot	1	---	900,000
Total				$1,800,000

OTHER EQUIPMENT SUMMARY: None

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1999 ESTIMATES

SUMMARY

SCIENCE, AERONAUTICS AND TECHNOLOGY

	Amount (Dollars)	Page No
Space Science:		
Modification of Stratospheric Observatory for Infrared Astronomy (SOFIA) Ground Support Facility	5,600,000	MS 4-17

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

PROJECT TITLE: Modification of Stratospheric Observatory for Infrared Astronomy (SOFIA) Ground Support Facility

INSTALLATION: Ames Research Center

FY 1999 Estimate: $5,600,000

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Space Science

FY 1998 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding	$436,000	---	$ 436,000
Capitalized Investment	---	$5,550,855	5,550,855
Total	$436,000	$5,550,855	$5,986,855

SUMMARY PURPOSE AND SCOPE:

This project modifies Hangar N-211 into a ground support facility for the 747-SP SOFIA aircraft. New laboratories and shops will be established to support the operations and maintenance of the SOFIA aircraft and the telescope assembly. The project constructs unique facilities such as a Mirror Coating Facility and a Telescope Simulator Laboratory. The project also upgrades the existing building systems, improving life safety and providing disabled person access to all floors in the facility, as required by law. The modifications proposed by this project are essential mission support elements of the SOFIA program.

PROJECT JUSTIFICATION:

SOFIA is being developed and will be operated for NASA by a team of industry experts led by the Universities Space Research Association. SOFIA will be the largest airborne telescope in the world, and will make observations that are impossible for even the largest and highest of ground-based telescopes. The aircraft platform, a Boeing 747-SP modified to accommodate a 2.5 meter reflecting telescope, will be based at Ames Research Center. The master SOFIA schedule requires the SOFIA aircraft to arrive at Ames Research Center by the end of 2000. In order to have the ground support facility finished and activated in time, the construction contract for this project must be awarded in October 1998.

Included in the project are facilities and equipment for mirror stripping and recoating, new laboratories to prepare and test experiments prior to installation on the SOFIA aircraft, modifications to improve the fire safety of the hanger, and modifications to improve compliance with the Americans with Disabilities Act. The laboratories and shops will support operations and maintenance of the SOFIA aircraft and the telescope assembly.

IMPACT OF DELAY:

Delay of this project will cause a day-for-day slip of the master program schedule for deployment and activation of the SOFIA observatory. The SOFIA primary mirror will be delivered uncoated directly from the factory to ARC. This project is being designed specifically around the requirement to coat the SOFIA mirror and will provide a unique capability that is not available anywhere else in the World. *Also,* if the facility is not ready to accept the aircraft when it arrives, the Government will incur additional costs for the temporary storage and maintenance of the aircraft and telescope assembly until this project is completed.

PROJECT DESCRIPTION:

The project provides for the construction (within the hangar) of a 240 square meter Mirror Coating Facility for the telescope primary mirror; a Telescope Simulator Laboratory to test experiments prior to installation on the aircraft: and laboratories and shops to support the SOFIA science operations. The project also provides for the installation of a hydraulic elevator: repair and upgrade of the heating, ventilation, and air conditioning system; modifications to the hanger wall and roof structure to accommodate the aircraft tail: modifications to the existing fire protection system, including the addition of underwing nozzles: and construction of a new 500 kVA substation to provide additional power to the facility.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Architectural/Structural	LS	---	---	$1,900,000
Mechanical/Fire Protection	LS	---	---	2,000,000
Electrical	Ls	---	---	500,000
Mirror Coating Facility	Ls	---	---	1,200,000
Total				$5.600.000

OTHER EQUIPMENT SUMMARY: None

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: None.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

SUMARY OF RESOURCE REQUIREMENTS

	Fiscal Year 1997	Fiscal Year 1998	Fiscal Year 1999	Page No
Discrete Projects	42,300	34,171	42,600	MS 4-21
Minor Revitalization	57,900	56,729	68,400	MS 4-49
Minor Construction	3,400	1,100	---	
Facility Planning and Design	18,700	19,000	14,000	MS 4-55
Environmental Compliance and Restoration	33,000	11,400	40,000	MS 4-59
TOTAL	155,300	122,400	165,000	
Distribution of Program Amount bv Installation				
Lyndon B. Johnson Space Center	17,901	4,993	11,790	
John F. Kennedy Space Center	9.821	15,284	30,390	
George C. Marshall Space Center	22,099	22,224	31,110	
John C. Stennis Space Center	5,171	12,350	9,100	
Ames Research Center	12,005	5,220	13,600	
Dryden Flight Research Center	13,228	6,897	2,520	
Langley Research Center	7,829	7,557	10,550	
Lewis Research Center	19,350	15,246	17,670	
Goddard Space Flight Center	24,106	14,469	18,940	
Jet Propulsion Laboratory	16,092	11,754	13,750	
Various Locations	3,011	3,505	3,240	
Headquarters	4,687	2,901	2,340	
TOTAL	155,300	122,400	165,000	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1999 ESTIMATES

SUMMARY

MISSION SUPPORT

Mission Support Discrete Projects:	Amount (Dollars)	Page No
Modernization of Process Cooling System, Numerical Aerodynamic Simulation Facility (ARC)	2,700,000	MS 4-22
Restoration of Electrical Distribution System (ARC)	2,200,000	MS 4-25
Restoration of Site Steam Distribution System (GSFC)	2,000,000	MS 4-28
Restoration of Space/Terrestrial Application Facility (GSFC)	5,000,000	MS 4-30
Construction of In-Situ Instruments Laboratory (JPL)	5,000,000	MS 4-32
Replacement of Central Plant Chilled Water Equipment (JSC)	3,000,000	MS 4-35
Replacement of High Voltage Load Break Switches (KSC)	2,200,000	MS 4-37
Upgrade of Utility Annex Chilled Water Plant (KSC)	1,900,000	MS 4-39
Rehabilitation of Instrument Research Laboratory (LaRC)	3,100,000	MS 4-41
Rehabilitation of High Voltage System (LeRC)	8,300,000	MS 4-44
Modification of Chilled Water System (MSFC)	7,200,000	MS 4-46
TOTAL DISCRETE PROJECTS	42,600,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

PROJECT TITLE: Modernization of Process Cooling System, Numerical Aerodynamic Simulation Facility

INSTALLATION: Ames Research Center

FY 1999 Estimate: $2,700,000

LOCATION OF PROJECT Moffett Field, Santa Clara County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Transportation Technology

FY 1998 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding	$200,000	---	$ 200,000
Capitalized Investment	---	$39,866,601	39,866,601
Total	$200,000	$39,866,601	$40,066,601

SUMMARY PURPOSE AND SCOPE:

This project will significantly increase the operational reliability of the Numerical Aerodynamic Simulation Facility (NASF)by providing an uninterrupted supply of chilled water required by the critical-task super-computers and other water-cooled equipment in Building N-258. Work includes installation of a thermal energy storage system, new non-chlorofluorocarbon (CFC)high energy efficiency chillers, and chilled water piping modifications to reduce energy consumption and improve system reliability. The NASF is required for Ames Research Center to perform its assigned Agency roles and missions. This project was included in the FY 1998 Budget Request but was deferred due to funding constraints.

PROJECT JUSTIFICATION:

Arnes Research Center is NASA's Center of Excellence for Information Technology and the NASF (Building N-258) is the "heart" of its information system structure. The facility houses the Von Nuemann and Eagle Cray C-90 supercomputers along with data storage, communication, and auxiliary equipment used by both local and national researchers networked into the systems.

The supercomputers and much of the other equipment are water-cooled, requiring an uninterrupted supply of chilled water to stay in operation. Loss of chilled water will cause the supercomputers to shut down within five minutes, disrupting the researchers tied into the computers. Even a brief shutdown causes loss of research data as well as hours of time to bring the computers back up. The critical nature of the computer load requires simultaneous operation of two chillers at all times. This results in excessive power consumption and accelerated chiller wear. The chillers are worn and have a remaining life projection of less than three years, increasing the likelihood of chiller failure and system shutdown.

This project greatly reduces the risk of chiller failure and also reduces the energy consumption of Building N-258, bringing it into compliance with Federal mandates to reduce overall energy use at NASA operated buildings. In addition, it replaces CFC refrigerant chillers with non-ozone-depleting refrigerant chillers.

IMPACT OF DELAY:

Delay of this project may result in loss of critical research data and downtime for the supercomputers of the NASF. This disrupts the work of a large number of researchers tied into this facility and the distribution of their research data Nationwide. Significant reductions in energy consumption and operations and maintenance costs will not be realized. The continued use of an expired refrigerant will have detrimental effects on the environment and will be increasingly expensive to stockpile for continued future use.

PROJECT DESCRIPTION:

This project replaces the four existing 700-ton chillers in Building N-258 with four new 500-ton chillers which use a non-ozone-depleting refrigerant. The project also provides an alternate electrical feed and installs a new thermal energy storage system to serve as emergency backup to the chillers.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Electrical and Communications	LS	---	---	$1,150,000
Mechanical and Plumbing	LS	---	---	1,500,000
Hazardous Materials Removal	LS	---	---	20,000
Systems Testing	LS	---	---	30,000
Total				$2,700,000

OTHER EQUIPMENT SUMMARY: None

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

PROJECT TITLE: Restoration of Electrical Distribution Svstem

INSTALLATION: Ames Research Center

FY 1999 Estimate: $2,200,000

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Transportation Technology

FY 1998 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding	$296,000	$2,400,000	$2,696,000
Capitalized Investment	---	4,316,543	4,316,543
Total	$296.000	$6.716.543	$7.012.543

SUMMARY PURPOSE AND SCOPE:

This project provides for selected repairs and upgrades to the Center's primary power distribution system, and the installation of a Center-wide power monitoring system. The existing electrical system at Ames is unreliable. In recent years there have been several power interruptions which have impact on critical research facilities, including the Numerical Aerodynamic Simulation Facility. The project provides metering at the main distribution feeders for the Center's wind tunnels and simulators, improves voltage regulation on the 13.8kV power system, and improves the protective relay system for better underground line protection. The primary power distribution system is required for ARC to perform its assigned Agency roles and missions.

PROJECT JUSTIFICATION:

The project provides for the construction and installation of a Center-wide power monitoring system, and for refurbishments to the Ames power distribution system. Voltage regulation has become a problem on the 13.8kV power system because of utility grid disturbances and because many of the more important computer facilities are on this system. The existing transformer tap changers are manual type and therefore require manual changing if the voltage level is not correct for the buildings. Automatic voltage tap changers will adjust without human intervention and also will provide and automatic means of equalizing bus voltages during tie switching. The power metering will provide a means of tabulating power and keeping track of electrical parameters necessary for planning, accurate billing, cost accounting, and determining the cost of power for wind tunnel operation. The new tie breaker will provide a safer and more convenient means of switching building feeders with one substation breaker instead of switching underground oil switches, shown in the past to be relatively unsafe. The new protective relay system was recommended in the past by Pacific Gas and Electric Company as a means of limiting ARC destruction during a heavy fault.

IMPACT OF DELAY:

Failure of Ames' electrical distribution system impacts mission-critical research and other activities across the Center. Potential impact of power outages include loss of data and substantial down time for facilities. Time and effort to recover lost data is significant. In addition, the cost and disruption associated with performing emergency repairs will be much higher.

PROJECT DESCRIPTION:

This project provides for the installation of power meters at the 115kV primary feeders and at selected 6.9 and 13.8kV feeders. It upgrades the protective relay system between the Pacific Gas and Electric Company substation and the ARC substation to provide better underground line protection. The project also provides for the upgrade of the 13.8kV power distribution system, including installation of a tie-breaker between Systems C and D, and a 15kV circuit breaker for each of the systems.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Power Monitoring System (PMS) Equipment	LS	---	---	$ 500,000
Installation of PMS Equipment	LS	---	---	650,000
Upgrade of Electrical Substation	LS	---	---	1,050,000
Total				$2,200,000

OTHER EQUIPMENT SUMMARY: None

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: A study is in progress to determine the full extent of the electrical problem at Ames Research Center. It is believed to be extensive and may possibly be in the $30-50 million dollar range.

PROJECT TITLE: Restoration of Site Steam Distribution Svstem

INSTALLATION: Goddard Space Flight Center

FY 1999 Estimate: $2,000,000

LOCATION OF PROJECT: Greenbelt, Prince George's County, Maryland

COGNIZANT HEADQUARTERS OFFICE: Office of Earth Science

FY 1998 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding	$160,000	---	$160,000
Capitalized Investment	---	$833,473	833.473
Total	$160,000	$993.473	$993,473

SUMMARY PURPOSE AND SCOPE:

This project provides for the restoration of selected portions of the site steam distribution system at the Goddard Space Flight Center. This project will replace various undersized and aging underground steam, condensate, and high pressure return piping: reduce operation and maintenance costs: and enhance the reliability and maintainability of the site steam distribution system.

PROJECT JUSTIFICATION:

The central steam distribution system was originally installed in the early 1960's and is at the end of its useful life. It is necessary to upgrade sections of the deteriorated steam/condensate lines on the main site to accommodate the increase in steam loads and provide a reliable steam loop for the new buildings on the East Campus. The piping and insulation have leaks and experience failures due to deterioration. Present failures in steam lines have resulted in elimination of some redundant loops, leaving buildings vulnerable to single point failure in aging steam lines. Some condensate and high pressure return lines have failed, requiring the condensate to be piped to drains. The result is the waste of water, energy, and treatment chemicals. In addition, the leakage of condensate to ground water is not allowed by environmental regulations. Extensive insulation failures have resulted in energy losses and damage to site landscaping and pavement.

IMPACT OF DELAY:

Delay of this project will jeopardize the site steam reliability and severely constrain sections of the site steam distribution system. A failure of the site steam distribution system would impact critical spacecraft operations at GSFC.

PROJECT DESCRIPTION:

The project provides for the replacement of steam and condensate lines from manhole 9a to manhole 13, from manhole 15 to manhole 17, of lines feeding Bldg. 5, and lines feeding Buildings 18, 19, and 20.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Construction				
Replace steam/condensate lines from MH 9A-13	LS	---	---	1,100,000
Replace steam/condensate lines from MH 15-17	LS	---	---	510,000
Replace steam/condensate lines to Bldg. 5	LS	---	---	90,000
Replace steam/condensate lines to Bldg. 18, 19, & 20	LS	---	---	300,000
Total				$2,000,000

OTHER EQUIPMENT SUMMARY: None

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: None. However, additional funding will be required in future years to restore other segments of the Site Steam Distribution System.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

PROJECT TITLE: Restoration of Space/Terrestrial Applications Facility

INSTALLATION: Goddard Space Flight Center

FY 1999 ESTIMATE: $5,000,000

LOCATION OF PROJECT Greenbelt, Prince George's County, Maryland

COGNIZANT HEADQUARTERS OFFICE: Office of Earth Science

FY 1998 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding.	$560,000	---	$ 560,000
Capitalized Investment	---	$7,982,876	7,982,876
Total	$560,000	$7,982,876	$8,542,876

SUMMARY PURPOSE AND SCOPE:

This project restores portions of architectural, mechanical, electrical, and fire protection/detection systems in the Space and Terrestrial Applications Facility, Building 22. The project corrects exterior and interior building system deficiencies in order to effectively support research operations conducted in this facility. Building 22 is required for Goddard Space Flight Center to perform its assigned Agency roles and missions. This project was included in the FY 1998 Budget Request but was deferred due to funding constraints.

PROJECT JUSTIFICATION:

Building 22 has been in service for 30 years. The existing systems have deteriorated and are beyond their projected useful life, which ranges from 20 to 30 years for critical mechanical and electrical system components. It is essential to restore those components likely to fail to maintain reliable support of the GSFC mission.

the required laboratory space to do the flight hardware testing and integration due to the phenomenal growth experienced as a technology innovator and provider of sensors for flight instruments. A detailed economic analysis has demonstrated that constructing this new building is more cost effective than modifying and maintaining the existing, substandard facilities.

IMPACT OF DELAY:

If the In-Situ Instruments Laboratory is not built, JPL will have to default on some of its commitments for currently planned planetary exploration missions in order to fit the work of highest priority within the available facilities. It would not be an option to carry-out the work under substandard conditions.

PROJECT DESCRIPTION:

This project will construct a new In-Situ Instruments Laboratory with Class 100,000 clean rooms and flight materials and parts storage areas. This structure will be approximately 1000 sm in size and partially occupy the site of existing Building 78 and Building 113, both of which are substandard, obsolete and will be demolished. Relocation of site utilities and construction of new retaining walls will be required.

The new structure will be a concrete frame on a concrete foundation. Vibration isolation will be provided for ultra-sensitive areas. At least one shielded room will also be provided. The exterior envelope will consist of factory fabricated wall panels, stucco, and bronze insulating glass. This structure will make use of existing air conditioning and electrical services capacity from the central power plant at Building 303 just west of this site. Humidity control and a quiet ground electrical system will be provided in test areas. This project will also require an oil mist exhaust system for the mechanical pumps and other services such as compressed dry air, vacuum, nitrogen, and cooling water. *An* electrostatic discharge ionization grid system with grounding straps is included. Interior walls will be drywall, ceiling will be suspended with ceiling panels and filters in the clean rooms. The flooring will be non-conductive sheet vinyl except in flight assembly areas where conductive flooring is required.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Sitework	LS	---	---	$ 500,000
Architectural/Structural	LS	---	---	2,000,000
Mechanical	Ls	---	---	1,900,000
Electrical	LS	---	---	600,000
Total				$5.000.000

OTHER EQUIPMENT SUMMARY: Liquid nitrogen tanks, furniture, computers, laboratory equipment, communications, and clean room outfitting totaling $2.5 million will be required.

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

PROJECT TITLE: Replacement of Central Plant Chilled Water Equipment

INSTALLATION: Johnson Space Center

FY 1999 Estimate: $3,000,000

LOCATION OF PROJECT Houston, Harris County, Texas

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1998 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding	$775.47 1	$ 9,700,000	$10,475,47 1
Capitalized Investment	-	9,374,703	9,374.703
Total	$775.471	$19,074,703	$19.850.174

SUMMARY PURPOSE AND SCOPE:

This project provides for the replacement of three cooling tower cells and associated equipment in the Central Heating and Cooling Plant, Building 24. Project need is driven primarily by critical need for reliable chilled water to support mission related institutional operations. This project is the third phase of a four year program that provides for the replacement of major cooling equipment in Building 24.

PROJECT JUSTIFICATION:

The existing cooling equipment in Building 24 has become increasingly unreliable, highly expensive to maintain, and has exceeded its 30-year life expectancy. A dependable chilled water supply is critical to the Center's ongoing air-conditioning and process cooling operations. The chilled water produced by this system supports all major mission-related and institutional buildings.

IMPACT OF DELAY:

Increased deterioration of cooling equipment and its related components will step up maintenance costs and will decrease the Central Heating and Cooling Plant's reliability. A failure of any of this equipment will disrupt the functions of the mission-critical buildings supported by this facility and could cause adverse program schedule delays.

PROJECT DESCRIPTION:

This project is the third of a four phase program that provides for the replacement of major cooling equipment in the Central Heating and Cooling Plant. This phase will replace three cooling tower cells with associated piping and controls and four new condenser water pumps. The work also includes dismantling and removal of the existing cooling tower cells: and abatement of pipe and turbine asbestos insulation, and chromate-contaminated soil around the cooling towers.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Replace Cooling Tower Cells and Ancillary Equipment	EA	3	$900,000	$2,700,000
Asbestos and Contaminated Soil Abatement	LS	---	---	200,000
Demolition	LS	---	---	100,000
Total				$3.000.000

OTHER EQUIPMENT SUMMARY: None

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: The fourth and final phase of this program is planned for FY 2000 with a cost estimate of $3,000,000.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

PROJECT TITLE: Replacement of High Voltage Load Break Switches

INSTALLATION: Kennedv Space Center

FY 1999 Estimate: $2,200.000

LOCATION OF PROJECT: Cape Canaveral, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1998 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding	$257,000	$3,100,000	$3,357,000
Capitalized Investment	---	31,162,000	31,162,000
Total	$257.000	$34,262,000	$34.519.000

SUMMARY PURPOSE AND SCOPE:

This project will replace high voltage manual type oil break switches to eliminate the explosive hazards associated with the operation and maintenance of oil-filled switches. This project is the fourth and final phase of a comprehensive activity to replace all 15kV load break switches centenvide.

PROJECT JUSTIFICATION:

These obsolete switches have caused a number of explosions that could potentially injure or kill operating personnel. Replacement parts are no longer available from the manufacturer and are increasingly difficult to maintain. It is an essential safety measure that these switches be replaced.

IMPACT OF DELAY:

Delay of this project will continue the use of obsolete oil break switches that are in violation of NASA safety standards and criteria. The possibility of a switch containing several gallons of oil exploding presents unacceptable risk of fire, injury and environmental pollution.

PROJECT DESCRIPTION:

The manual type oil load break switches are to be replaced with newer style switches incorporating compression spring operators. Switch ratings will be increased from 400 amps to 600 amps with close-into-fault ratings of 40,000 amps. The system will be converted from oil to sulfurhexafloride (SF-6)as recommended by our Reliability and Quality Assurance experts.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Switches and Associated Equipment	LS	1	1,800,000	$1,800,000
Installation	LS	1	400,000	400,000
Total				$2,200,000

OTHEK EQUIPMENT SUMMARY: None

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

PROJECT TITLE: Upgrade of Utilitv Annex Chilled Water Plant

INSTALLATION: Kennedv Space Center

FY 1999 Estimate: $1,900,000

LOCATION OF PROJECT Kennedy Space Center, Brevard County, Cape Canaveral, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1998 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding	$540,000	$ 4,000,000	$ 4,540,000
Capitalized Investment	---	8,757,293	8,757,293
Total	$540,000	$12,757,293	$13,297,293

SUMMARY PURPOSE AND SCOPE:

The central utility annex contains five outdated chillers with a total cooling capacity of 11,500 tons. Refurbishment and upgrades to three of these chillers is in a FY 1998 CoF project. This project will refurbish and upgrade the remaining two chillers and upgrade the total cooling capacity of the plant to handle present day demand for chilled water. Then, facilities with individual chiller units in need of repair can be connected to the central chiller plant, avoiding the costly replacement of these individual chiller units.

PROJECT JUSTIFICATION:

The existing chillers are over 30 years old, experience increased unscheduled outages including a recent catastrophic failure due to excessive component wear, use the environmentally unacceptable refrigerant CFC-12, and are highly energy inefficient. Further, existing plant capacity is insufficient to support the cooling requirements of facilities scheduled to be connected to the chiller plant over the next three years.

IMPACT OF DELAY:

Failure to upgrade or replace deteriorated equipment continues the risk that unscheduled outages will increasingly interfere with KSC's ability to meet critical mission schedule milestones. Escalating maintenance and repair costs will increase continually, particularly as a result of the recent termination of production and importation of all CFC-12 refrigerant. Ongoing cooling operations will become marginal as additional facilities are connected and activated.

PROJECT DESCRIPTION:

This project refurbishes and upgrades two chillers located in the north area utility annex, Building K6-947. Refurbishment work includes rebuilding the gear boxes, reconditioning the motors, and converting the compressors from CFC-12 to HCFC-134A. Upgrade work includes retubing of the evaporators and condensers, modifying the refrigerant storage and transfer system, and upgrading the control system.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Controls	LS	---	---	$ 100,000
Mechanical	I s	---	---	1,750,000
Electrical	I s	---	---	50,000
Total				$1,900,000

OTHER EQUIPMENT SUMMARY: None

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

CONSTRUCT1ON OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

PROJECT TITLE: Rehabilitation of Instrument Research Laboratory

INSTALLATION: Langley Research Center

FY 1999 Estimate: $3,100,000

LOCATION OF PROJECT Hampton, Virginia

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Transportation Technology

FY 1998 AND PFUOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding	$307,000	---	$ 307,000
Capitalized Investment	---	$4.518,013	4.518,013
Total	$307,000	$4,518,013	$4,825,013

SUMMARY PURPOSE AND SCOPE:

This project rehabilitates the Instrument Research Laboratory, Building 1230, with emphasis on the mechanical systems in the West Wing. Building systems will be upgraded to comply with current standards and to achieve full functionality and efficiency. The building contains offices, laboratories, conference rooms, and computer rooms. Each type of space will be treated accordingly. The bulk of space in Building 1230 is utilized for technical support and/or technology development laboratories that support all of LaRC's ground facilities based research and development activities in aerodynamics, aerothermodynamics, structures, and materials disciplines as well as the area of Non-Destructive Evaluation Sciences.

PROJECT JUSTIFICATION:

Building 1230 is 50 years old and the last significant rehabilitation was 18 years ago. The frequency of emergency repair calls for the HVAC and mechanical systems is 3 to 5 times higher than the average for buildings of similar size. There have been 6-10 major repairs and about 75 short and urgent repairs each year over the last three years. Maintenance costs are averaging four times those of a comparable building at the Center.

Relatively minor repairs can cause significant disruptions. A lab may have to be vacated for a plumbing repair because the pipe is wrapped with asbestos insulation. Productivity impacts to temperature sensitive paint development, cryogenic balance calibration, model aeroelastic deformation measurement development, and data systems development have delayed delivery of test support for major wind tunnel facilities.

IMPACT OF DELAY:

This facility houses many labs and personnel critical to the Center mission. Failure to make timely restoration of this building risks significant disruptions to ongoing work. Delay will increase costs and disrupt program schedules.

PROJECT DESCRIPTION:

Existing metal pan and spline type ceiling systems will be replaced with a new acoustical tile ceiling system. Spray applied asbestos insulation located above the ceiling areas of the West Wing's second and third floors will be removed. Asbestos floor tiles in the West Wing will be removed and replaced with vinyl composition tiles or carpet, depending on the function of the particular room. Existing light fixtures will be replaced with new energy efficient lighting. A wet pipe sprinkler fire protection system will be installed throughout the building consistent with NASA policy. The existing fire alarm system will be replaced or upgraded, as required.

The HVAC systems of the West Wing will be replaced, except in the second floor computer room, including removal of asbestos covered piping and ductwork. The new system will utilize hot water for heating and chilled water for cooling. Hot water will be generated by a new steam to hot water converter and chilled water will be supplied from the existing absorption chiller located in the East Wing basement. **A** direct digital control system with individual room control will be provided.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Asbestos Abatement	LS	1	$ 425,000	$ 425,000
Architectural/Structural	LS	1	672,000	672,000
Mechanical	LS	1	1,270,000	1,270,000
Electrical	LS	1	733,000	733,000
Total				$3,100,000

OTHER EQUIPMENT SUMMARY: None

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

PROJECT TITLE: Rehabilitation of High Voltage Svstem

INSTALLATION: Lewis Research Center

FY 1999 CoF ESTIMATE: $8,300,000

LOCATION OF PROJECT Cleveland, Cuyahoga County, Ohio

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Transportation Technology

FY 1998 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding	$1,740,000	$ 9,000,000	$ 10,740,000
Capitalized Investment	---	24,998,000	24,998,000
Total	$1,740,000	$33,998,000	$35,738,000

SUMMARY PURPOSE AND SCOPE:

This project is the second of three phases that will rehabilitate and modify the Lewis Research Center's (LeRC)existing High Voltage Power System. The project is required to assure continued reliability and safe electrical power supply at LeRC. The system distributes power to all of the Center's aerospace research and development facilities, computer center, and the institutional facilities.

PROJECT JUSTIFICATION:

This system provides power to the major aeropropulsion and space simulation facilities. It is 50 years old, obsolete, and experiencing increased maintenance and emergency repairs each year. Current circuit breaker overloads and single point failures warn of a major failure that could result in a 6 to 12-month shutdown. Economic analysis indicates this project is the most cost-effective approach to maintain an operating system for the next 30 years.

IMPACT OF DELAY:

Unless the system is rehabilitated, failure rates currently being experienced are expected to increase. Major disruptions of electrical services, associated with single point failures, are also anticipated. These failures will result in the shutdown of critical research facilities and the programs they support for periods of **up** to 12 months.

PROJECT DESCRIPTION:

This project replaces the A2 and A3, 138kv transformers at Substation A, replaces all 34.5kv insulators, disconnect switches, grounding transformers, and breakers: and expands the control house at Substation A. It also replaces 34.5kv transformers and cabling at Substations D and E: installs 2.4kv switchgear at Substation E; adds a 34.5kv breaker at Substation K; replaces 34.5kv breakers and current limiting reactors: adds a station power transformer at Substation B; and installs a solid state variable frequency drive starting system in Building 64.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Substation A modifications	LS	---	---	$ 3,100,000
Substation B modifications	LS	---	---	1,500,000
Substation K modifications	LS	---	---	200,000
Substation D and E modifications	LS	---	---	2,000,000
Solid State Variable Frequency Starting System	LS	---	---	1,500,000
Total				$ 8.300.000

OTEIER EQUIPMENT SUMMARY None

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: None. However, funding will be required in future years to rehabilitate other elements of the Electrical Distribution System.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

PROJECT TITLE: Modification of Chilled Water System

INSTALLATION: Marshall Space Flight Center

FY 1999 Estimate: $7,200,000

LOCATION OF PROJECT: Marshall Space Flight Center, Madison County, Alabama

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1998 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific Construction Funding	$1,599,000	$13,400,000	$14,999,000
Capitalized Investment	---	---	---
Total	$1.599.000	$13,400,000	$14.999.000

SUMMARY PURPOSE AND SCOPE:

This project further expands the central chiller plant and chilled water distribution system approved by Congress for construction in FY 1997 and 1998 to additional areas of the Center. It converts the chilled water system from individual chiller units to a central chiller plant with a chilled water (pipeline) distribution system. The project will significantly reduce operations, maintenance, and energy costs; improve reliability in support of critical operations; and help phase out the use of existing refrigerants which are no longer in production. The chilled water system supports facilities required for Marshall Space Flight Center to perform its assigned Agency roles and missions.

PROJECT JUSTIFICATION:

The Center presently air conditions its facilities and equipment with chilled water produced by individual chillers in each building. These chillers are often backed up with a spare chiller due to redundancy requirements. Consolidating service out of a central chiller plant reduces the total capacity required and the overall cost involved in providing the same level of redundancy. This project also avoids a huge maintenance and repair backlog. Existing chillers affected by this project are old, unreliable, and use refrigerants which are no longer in production. New chillers compatible with the new refrigerants require chiller equipment rooms to be extensively modified, and sometimes relocated, due to the toxic nature of the new refrigerants which require additional ventilation and leakage detection and alarm systems. Expanding the central chiller plant and distribution system to extend service to additional building areas with multiple individual units will eliminate disruptions associated with piecemeal repairs and will pay for itself in seven to eight years.

IMPACT OF DELAY:

Failure of the existing chillers results in downtimes for extensive repairs that are disruptive to the operation of the Center and which require costly work-arounds such as leasing of emergency chillers. Chillers will continue to be replaced individually which is an inefficient financial investment. Failure to convert to the new refrigerants will also require accumulation and stockpiling of the old refrigerant at continually escalating premium prices.

PKOJECT DESCRIPTION:

This project expands the central chiller plant and chilled water distribution system approved by Congress for construction in FY 1997 and 1998. Scope includes the acquisition and installation of additional cooling tower cells, chillers, and associated mechanical and electrical equipment to extend service to additional areas. This project will extend the 4200 and 4400 loops to capture additional buildings in those areas and constructs the loops that will provide service to the 4600 and 4700 areas.

PROJECT COST ESTIMATE:

	Unit of Measure	Quantity	Unit Cost	Cost
Mechanical	LS	---	---	$700,000
Electrical	Ls	---	---	500,000
Distribution System and Hook-up	Ls	---	---	6,000,000
Total				$7,200,000

OTHER EQUIPMENT SUMMARY: None

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED TO COMPLETE THIS PROJECT: None

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

SUMMARY

MINOR REVITALIZATION

Location:

	Amount
Ames Research Center	$ 5,290,000
Dryden Flight Research Center	1,220,000
Goddard Space Flight Center	7,300,000
Jet Propulsion Laboratory	4,560,000
Johnson Space Center	3,350,000
Kennedy Space Center	11,300,000
Langley Research Center	6,140,000
Lewis Research Center	5,000,000
Marshall Space Flight Center	10,100,000
Michoud Assembly Facility	5,400,000
Stennis Space Center	4,700,000
Wallops Flight Facility	1,700,000
Various Locations	2,340,000
Total	$68,400,000

PROJECT TITLE: Minor Revitalization of Facilities, Not in Excess of $1,500,000 Per Project

INSTALLATION: Various Locations

FY 1999 Estimate: $68,400,000

FY 1997: $57,900,000 FY 1998: $56,100,000

COGNIZANT INSTALLATIONS/LOCATIONS OF PROJECT Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of Management Systems and Facilities

SUMMARY PURPOSE AND SCOPE:

These resources provide for revitalization of facilities at NASA field installations and Government-owned industrial plants supporting NASA activities. The request includes facility revitalization needs for FY 1999 that are greater than $500 thousand but not in excess of $1.5 million per project. Revitalization projects provide for the repair, rehabilitation, and/or modification of facilities and collateral equipment. Repair projects restore facilities and components thereof, including collateral equipment, to **a** condition substantially equivalent to their originally intended and designed capability. Repair work includes the substantially equivalent replacement of utility systems and collateral equipment necessitated by incipient or actual breakdown and major preventive measures that are normally accomplished on a cyclic schedule. Rehabilitation and modification projects may include some restoration of current functional capability but also includes enhancement of the condition of a facility so that it can more effectively accomplish its designated purpose or increase its functional capability. The facilities being revitalized in this program are expected to remain active in the long term and are consistent with current and anticipated Agency roles and missions.

PROJECT JUSTIFICATION:

NASA is now experiencing "block obsolescence" where a substantial portion of the agency's facilities have been in use for over 30 years. Repair costs for mechanical and electrical systems in a typical building are almost three times higher after system operations exceed 15–20 years than they are during the initial years. Many electrical and mechanical components reach the end of their serviceable or economic life at the 20 year point and should be replaced in the interest of long-term economy. Continued piecemeal repair of these components is more costly in the long run than replacement at the end of the economic life of the original components. Approximately 90 percent of NASA's physical plant has been in service for over 25 years.

The NASA physical plant has a capital investment of $6.1 billion and has a current replacement value of more than $17 billion. **A** continuing program of revitalization of these facilities is required to accomplish the following:

a. Protect the capital investment in these facilities by minimizing the cumulative effects of wear and deterioration.

b. Ensure that these facilities are continuously available and that they operate at peak efficiency.

c. Improve the capabilities and usefulness of these facilities and thereby mitigate the effects of obsolescence.

d. Provide a better and safer environment for all personnel.

e. Avoid significantly greater future repair costs.

In past years, this program included revitalization work exceeding $200 thousand per project. Beginning in FY 1999, the program includes revitalization work that exceeds $500 thousand per project. Projects $500 thousand and less in magnitude are normally accomplished by routine day-to-day facility maintenance and repair activities provided for in Human Space Flight: Science, Aeronautics and Technology; and Mission Support appropriations. Projects estimated to cost more than $1.5 million are included as separate discrete projects in the budget request.

PROJECT DESCRIPTION:

Proposed projects for FY 1999 totaling $73.4 million are identified under "MINOR REVITALIZATION PROJECT COST ESTIMATE." The projects that comprise this request are of the highest priority based on relative urgency and expected return on investment. Deferral of this mission-essential work would adversely impact the availability of critical facilities and program schedules.
The titles of the projects are designed to identify the primary intent of each project and may not always capture the entire scope or description of each project. *Also*, during the year, some rearrangement of priorities may be necessary which may force a change in some of the items to be accomplished. Any such changes, however, will be accomplished within total available revitalization resources.

MINOR REVITALIZATION PROJECT COST ESTIMATE:

A. Ames Research Center (ARC)	$5,290,000
1. Mechanical and Structural Modifications to Upgrade Performance and Improve Safety of the Model Support/Scale System, 40x80 Wind Tunnel	1,500,000
2. Upgrade Emergency Power Supply System, (N-233, N-233A)	1,430,000
3. Repair Electrical and Heating, Ventilation and Air Conditioning (HVAC) Systems, Bioscience Laboratory (N-236)	1,250,000
4. Repair Selected Mechanical and Electrical Systems, Unitary Plan Wind Tunnel (N-227)	1,110,000
B. Drvden Flight Research Center (DFRC)	$1,220,000
1. Install Seismic Reinforcement to Structural, Electrical, Mechanical & Other Systems, Building 4820	700,000
2. Replace Boilers and Piping in the Central Steam Distribution System	520.000
C. Goddard Space Flight Center (GSFC)	$7,300,000
1. Replace Exterior Metal Panel System of Space Projects Building (1)	700,000
2. Repair Roofs, Exteriors, and Foundations, Various Buildings	1,050,000
3. Repair Rooms and Electrical Load Centers and Distribution Systems, Various Buildings	1,100,000
4. Repair and Modify Storm Drainage System Piping, Drainage Inlets and Manholes	600,000
5. Modifications for Disabled Accessibility Building 25	700,000
6. Repair HVAC Systems and Controls, Various Buildings	800,000
7. Repair Fire Protection and Domestic Water Piping System	650,000
8. Repair Office Area, HVAC, Fire Alarm, and Suppression Systems, Various Buildings	900,000
9. Restore Heating, Ventilation, and Air Conditioning (HVAC) Systems, Building 23	800,000
D. Jet Prooulsion Laboratorv (JPL)	$4,560,000
1. Install Fire Sprinkler System Building 238	1,000,000
2. Replace Fire Detection and Alarm Systems, Various Buildings	600,000
3. Replace and Increase Capacity of Mesa Transformer Bank #52	950,000
4. Replace Air Handlers and Heating, Ventilation, and Air Conditioning (HVAC) Controls Building 230	1,410,000
5. Replace Plumbing Systems and Modify Restrooms for Code Compliance, Building 230	*600,000*

E. Johnson Space Center (JSC)	$3,350,000
1. Repair and Upgrade Fire Alarm and Sprinkler Systems (5 & 16)	600,000
2. Replace Roofs (1, 30A, and 30 MOW)	1,150,000
3. Upgrade Low Voltage Electrical System Sitewide	700,000
4. Repair and Modernize Air-conditioning Systems, Various Buildings, White Sands Test Facility	900,000
F. Kennedv Space Center (KSC)	$11,300,000
1. Repair Mechanical Equipment and Building Systems, Fire Pumphouse (K6-895)	1,100,000
2. Repair and Upgrade Fire Detection System, Orbiter Processing Facility #1	700,000
3. Repair and Modernize Fire Alarm System, Various NASA Facilities, Cape Canaveral Air Force Station	800,000
4. Repair and Upgrade 15kV Feeder to Launch Pads A and B	650,000
5. Modifications for Disabled Accessibility, Various Facilities	550,000
6. Repair Elevator Controls, Vehicle Assembly Building	1,000,000
7. Repair and Upgrade Lighting System, Launch Control Center	950,000
8. Repair Elevator Controls, Launch Control Center	550,000
9. Repair and Modernize Equipment in Mechanical Rooms, Launch Control Center and Vehicle Assembly Building	1,400,000
10. Repair and Modernize Low Voltage System, LC-39 Area	900,000
11. Upgrade Electrical Substation, Central Information Facility	900,000
12. Modifications to Provide Support Annex for Payload Processing (M7-1104)	800,000
13. Repair Pavements, Various Locations	1,000,000
G. Langley Research Center (LaRC)	$6,140,000
1. Modify the Exhaust Line and Diffuser Section, 20-Inch Supersonic Wind Tunnel (B1247D)	1,410,000
2. Repair Mechanical and Electrical Systems for Automated Control of Model Carts, 14x22-Foot Wind Tunnel (B1212C)	930,000
3. Upgrade Test Section, Flexwall System, .3-Meter Transonic Cryogenic Tunnel (B1242)	1,100,000
4. Replace Water Pump Drive Control System for Arc Heated Scramjet Test Facility (B1247B)	1,300,000
5. Replace Nozzle, 20-Inch Mach 6 Wind Tunnel	1,400,000

H.	Lewis Research Center (LeRC)	$5,000,000
	1. Repair Natural Gas System Piping, Valves, and Manholes	660,000
	2. Repair Sewer System Main Pumping Station	900,000
	3. Repair Heating, Ventilation, Air Conditioning, Electrical, Fire Alarm and Suppression Systems, Energy Conversion Laboratory (302)	1,000,000
	4. Repair Heating, Ventilation, Air Conditioning and Fire Suppression Systems, Instrument Research Laboratory (77)	900,000
	5. Repair Heating, Ventilation, Air Conditioning Fire Alarm and Suppression Systems, Model Fabrication and Installation Facility (14)	900,000
	6. Repair Heating, Ventilation, Air Conditioning Fire Alarm and Suppression Systems, Imaging Technology Center, Engine Research Building (5)	640,000
I.	Marshall Space Flight Center (MSFC)	$10,100,000
	1. Replace Piping, Valves, and Components, High Pressure Gas Distribution System	800,000
	2. Replace Roof of Office Building (4666)	800,000
	3. Replace Roof and Repair Heating, Ventilation, and Air Conditioning (WAC) System, Solid Rocket Booster Parachute Refurbishment Facility	1,500,000
	4. Replace Sections of Roof Structural Dynamics and Thermal Vacuum Laboratory (4619)	1,400,000
	5. Repair and Modernize Interior Building Systems, Office and Testing Facility (4732)	1,450,000
	6. Repair and Modernize Electrical and Mechanical Systems, Developmental Processes Laboratory (4711)	1,400,000
	7. Modifications for Optical Fabrication and Metrology Activities, Process Development Laboratory (4487)	950,000
	8. Modifications for Large Diameter Replicated Optics Plating Activities, Air Compressor Facility (4747)	1,100,000
	9. Safety Modifications to Overhead Cranes, Various Locations	700,000
J.	Michoud Assemblv Facilitv (MAF)	$5,400,000
	1. Repair Mechanical Components in Fanhouses, External Tank Manufacturing Building (103)	950,000
	2. Repair Dehumidifiers, Vertical Assembly Building (110, 114)	900,000
	3. Repair Electrical System, Industrial Wastewater Treatment Plant (173)	800,000
	4. Replace Chillers, Systems Engineering Building and Boiler House (130,207)	950,000
	5. Replace Mechanical Equipment and Perform Structural Repairs, Main Pumping Station (450)	850,000
	6. Repair and Upgrade Potable Water System, Various Facilities	950,000

K. Stennis Space Center (SSC)	$4,700,000
1. Repair Pavements, Various Locations	700,000
2. Repair High Voltage Canal Crossings and Power Poles	800,000
3. Repair Cryogenic and High Pressure Gas Components, Test Complex	700,000
4. Repair and Modernize Heating, Ventilation, and Air Conditioning (HVAC), Various Facilities	950,000
5. Repair and Modernize Energy Management Control Systems, Various Facilities	750,000
6. Restore and Modernize Building Systems, Shop Facilities (2201, 2205)	800,000
L. Wallops Flight Facility (WFF)	$1,700,000
1. Repair Roofs, Heating, Ventilation, Air Conditioning and Electrical Systems, Various Buildings	800,000
2. Repair Storm Drain System, Main Base & Island	900.000
M. Various Locations	$2,340,000
1. Replace Motor Control Center, 70M Subnet, Canberra, Australia: Goldstone, CA; & Madrid, Spain	600,000
2. Install New Chillers, Piping, and Controls for Chilled Water System, Madrid, Spain	1,200,000
3. Repair Pavements, Goldstone, CA	540,000
Total Minor Revitalization	$68,400,000

FUTURE ESTIMATED CONSTRUCTION FUNDING REQUIRED:
Approximately $70-75 million per year will be required for continuing minor revitalization needs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

SUMMARY

FACILITY PLANNING AND DESIGN

	Amount
Master Planning	$ 400,000
Sustaining Engineering Support	1,000,000
Project Planning and Design Activities	12,600,000
Total	$14.000.000

PROJECT TITLE: Facilitv Planning and Design

FY 1999 Estimate: $14,000,000

FY 1997: $18,700,000	FY 1998: $19,000,000

These funds are required to provide for the following advance planning and design activities related to facilities activities and projects where not otherwise provided for:

a. The accomplishment of necessary studies: development and master planning for field installations: and the provision of continuing engineering support, special engineering management, and other services.

b. The preparation of preliminary engineering reports, cost estimates, and design and construction schedules. Also includes the preliminary engineering efforts required to initiate design-build projects.

c. The preparation of final designs which include construction plans, specifications, and associated cost estimates and schedules required to implement construction projects.

d. The accomplishment of facilities siting and other investigations, studies and reports.

e. Participation in facilities related professional associations.

A. Master Planning $400,000

Provides for updating, developing and automating existing field installation master plans. This effort includes facility studies, site investigations, and analyses of utility systems. The existing utility and civil drawings will be converted into a highly detailed electronic database using computer-aided-design (CAD) systems. Topographical features from original drawings will be merged electronically to create individual area maps or an entire center map. The master plan documents will be updated to reflect as-built conditions and to graphically represent the 5-year facility plan baseline for future development.

The NASA field center master plans are periodically updated. The master plans are essential as reference documents for land use planning, identification of physical relationships of facilities, and proper orientation and arrangement of facilities. The updates reflect as-built condition of facilities and utility systems with emphasis on changes caused by recent facility construction and modifications.

B. Sustaining Engineering Support $1,000,000

Provisions for facility studies and specific engineering support continue in importance as evidenced in recent years. These efforts are important due to changing cost trends in construction materials and fuels; the operation and maintenance costs for the physical plant; and energy conservation and efficiency.

The following items are included in the FY 1999 requirements:

1. Facilities Engineering Design and Construction Management Studies - This effort involves extremely high leverage facility studies that are critically important to improve the quality and cost effectiveness of NASA's construction practices and to ensure that developing technology and industry best practices are incorporated into the agency's construction program.

2. Value Engineering, Cost Validations and Analyses - Provides for engineering services to improve cost-effectiveness of facility projects by subjecting project design criteria, specifications and working drawings for specific material components and systems to detailed independent reviews by engineering specialists. Also provides services necessary to predict and validate facility costs to aid in resources planning.

3. Facility Operation and Maintenance - Provides for studies and engineering support where not otherwise provided for, at NASA field installations relative to functional management of maintenance, automated maintenance management systems, and facilities condition assessments. Included in this activity are field surveys to be conducted at selected NASA field installations to evaluate the effectiveness and efficiency of the operations and maintenance management activities, and to identify possible improvements in productivity.

4. Facilities Utilization Analyses - Provides for the analyses of agencywide facilities utilization data covering (1)office and other types of building space; (2)designated major technical facilities; and (3)special studies comparing the utilization of technical facilities which are similar in type or capability, such as wind tunnels. Such analyses provide for (1)insights into and development of better methods of identifying underutilized facilities; (2)improved techniques to quantify level of facilities use: (3)actions to improve facilities utilization; and (4)recommendations regarding consolidation/closure of facilities to meet Agency physical plant reduction objectives. Work provides for review of each installation's inventory data base in support of the facilities utilization program. Surveys are necessary to validate the reported data in relation to a specific problem or need, and to assist in providing a credible foundation for plans to improve the use of facilities.

5. Facilities Management Systems - Provides for continued engineering support for technical updating of NASA's master text construction specifications to reflect the use of new materials, state-of-the-art construction techniques and current references to

building codes and safety standards. Also provides engineering support for the Major Facilities Inventory, the Real Property Database and the Facilities Utilization Database systems.

6. Construction Industries Institute - Covers annual support to the Construction Industries Institute (CII). NASA actively participates in this unique, non-profit institution, established to bring together major facility owners, contractors and academia in a proven effort to improve the quality and cost effectiveness of construction management practices for member organizations as well as the U S construction industry.

7. National Research Council - Covers annual support to the Federal Facilities Council's (FFC) operations, in which NASA participates, and provides for special studies that the Council will perform to help advance the science and technology of Federal Government building and construction. The FFC is subordinate to the National Research Council of the National Academy of Sciences, and its activities are supported by NASA and other Federal agencies with similar construction programs.

C. Project Planning and Design Activities $12,600,000

1. Preliminary Engineering Reports (PERs) (1,100,000)

This estimate provides for preparation of PERs, investigations, project studies and other pre-project planning activities related to proposed facility projects in the FY 2001 and FY 2002 Construction of Facilities programs. These reports are required to permit the early and timely development of the most suitable project to meet the stated programmatic and functional needs. Reports provide basic data, cost estimates and schedules relating to future budgetary proposals.

2. Related Special Engineering Support (400,000)

This estimate provides for investigations and project studies related to proposed facility projects to be included in the subsequent Construction of Facilities programs. Such studies involve documentation and validation of "as-built" conditions, survey/study of present condition of such items as roofing and cooling towers, utility plant condition and operational modes, and other similar studies. These studies are required to allow for the timely development of projects to meet the stated functional needs and to provide basic data, cost estimates and schedules for related future budgetary proposals.

3. Final Design (11,100,000)

The amount requested will provide for the preparation of designs, plans, drawings, and specifications necessary for the accomplishment of construction projects. Also provides technical and engineering support analyses, designs, and reviews required to verify, confirm and ensure suitability of construction designs within the project cost estimates. This work is associated with construction proposed for the FY2000 and FY 2001 program. The goal is to obtain better facilities on line earlier at a lower cost.

Total Facility Planning and Design $14,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1999 ESTIMATES

SUMMARY

ENVIRONMENTAL COMPLIANCE AND RESTORATION PROGRAM

Summary of Project Amounts by Location:	Amount
Ames Research Center	$1,850,000
Dryden Flight Research Center	400,000
Jet Propulsion Laboratory	3,150,000
Johnson Space Center	1,500,000
Kennedy Space Center	8,110,000
Lewis Research Center	2,500,000
Marshall Space Flight Center	4,715,000
Michoud Assembly Facility	1,500,000
Stennis Space Center	3,750,000
Wallops Flight Facility	400,000
White Sands Test Facility	2,000,000
Remedial Investigations, Feasibility Studies, Assessments, Studies Designs, Related Engineering, and Remedial Sampling and Monitoring,	10,125,000
Total	$40,000,000

PROJECT TITLE: Environmental Compliance and Restoration Program

INSTALLATION: Various Locations

FY 1999 Estimate: $40,000,000

FY 1997: $33,000,000

FY 1998: $11,400,000*

COGNIZANT INSTALLATIONS/LOCATIONS OF PROJECT Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of Management Systems and Facilities - Environmental Management Division

SUMMARY PURPOSE AND SCOPE:

These resources will provide for environmental activities including: projects, studies, assessments, investigations, plans, designs and related engineering for environmental compliance and restoration measures, and for required sampling, monitoring and other activities associated with remedial treatment processes. These activities will be performed at NASA field installations, Government-owned industrial plants supporting NASA activities, and other locations where NASA operations have contributed to environmental problems and NASA is obligated to contribute to cleanup costs. In addition, these resources will be used to provide for regulatory agency oversight costs, to acquire land if necessary to implement environmental compliance and restoration measures, and to perform studies and assessments in support of functional leadership initiatives related to environmental compliance and restoration activities. The purpose of this program is to enable NASA to comply with environmental statutory and regulatory requirements and standards, cleanup orders, and regulatory/cooperative agreements. The resources authorized and appropriated pursuant to this program may not be applied to other activities. The program includes studies or assessments to determine compliance status and options for remedial actions, including evaluations and use of new cleanup technologies, and to support environmental initiatives: conduct of prescribed remedial investigations and feasibility studies as required by environmental laws and regulations; performance of environmental restoration, hazardous waste removal and disposal, cleanups, and closures: and environmental compliance activities.

The FY 1998 program is reduced $22.6 million from the budget request of $34 million. Prior year uncosted backlog will be used to accomplish the FY 1998 program.

PROJECT JUSTIFICATION/DESCRIPTION:

Proposed environmental compliance and restoration activities for Fiscal Year 1999 total $40.0 million. This program represents this year's request on a phased approach in relation to the total requirements for environmental remediation that must be implemented within the next several years, as well as needed requirements for other environmental compliance measures. Based on relative urgency and potential health hazards, the listed activities are the highest priority requirements currently planned for accomplishment in FY 1999. Deferral of necessary compliance and remedial measures would preclude NASA from complying with environmental requirements and regulatory agreements, and jeopardize critical NASA operations. As studies, assessments, remedial investigations, feasibility studies, and designs progress and as new discoveries or regulatory requirements change, it is expected that priorities may change and revisions of these activities may be necessary.

Remediation activities include one or more phases of a site cleanup program, including but not limited to, the following: 1) site assessments: 2) site investigations; 3) interim cleanup actions: 4) testing and evaluation; and 5) remedial treatment processes and other activities associated with the Comprehensive Environmental Response, Compensation and Liability Act/Resource Conservation and Recovery Act (CERCLA)/RCRA) cleanup requirements.

The following broad categories summarize the effort to be undertaken with the identified estimated costs

a.	Remediation Activities - Hazardous Waste Corrective Actions/Cleanups (CERCLA, RCRA)	$36,618,000
b.	Other Environmental Compliance Requirements (Clean Air Act (CAA), Clean Water Act (CWA), Resource Conservation and Recovery Act (RCRA), Endangered Species Act (ESA))	3,382,000

COST ESTIMATES:

A. Ames Research Center (ARC)	$1,850,000
1. Remediate Contamination at Area of Investigation No. 5 - Various Sites	600,000
2. Remediate Contamination at Area of Investigation No. 11 - UST Sites	500,000
3. Remediate Contamination at Area of Investigation No. 12 - N2 11	750,000
B. Dryden Flight Research Center (DFRC)	$400,000
1. Remediation of Soil/Groundwater Contamination	400,000
C. Jet Propulsion Laboratory (JPL)	$3,150,000
1. Remediation of Arroyo Seco Groundwater Contamination	2,600,000
2. Air Pollution Control Units	550,000
D. Johnson Space Center (JSC)	$1,500,000
1. Remediation of Groundwater, Monitoring Well No.2 Area	300,000
2. Environmental Assessment/Cleanup for NASA Industrial Plant, Downey	400,000
3. Closure of Impoundment and Process Sewer Relocation	800,000
E. Kennedy Space Center (KSC)	$8,110,000
1. Remediation of Launch Complex 36	1,000,000
2. Remediation of M7-505 Waste Treatment Tank Site	1,500,000
3. Remediation of RP-JP Facility Site	1,000,000
4. Remediation of Components Cleaning Facility Laboratory	2,000,000
5. Remediation of Wilson's Corner Site, Phase 2	750,000
6. Remediation of VAB Utility Annex	250,000
7. Remediation of Ramson Road Sandblast Area	250,000
8. Restoration of Wetlands and Scrub Habitat	610,000
9. Various Interim Remedial Actions, Various Locations	750,000
F. Lewis Research Center (LeRC)	$2,500,000
1. Remediation of Contaminated Sites, Cleveland	2,500,000
G. Marshall Space Flight Center (MSFC)	$4,715,000
1. CERCLA Investigation and Cleanup	3,715,000
2. RCRA Investigation and Cleanup, Santa Susana Field Laboratory (SSFL)	500,000
3. Cleanup of Groundwater Contamination, Santa Susana Field Laboratory (SSFL)	500,000

H. Michoud Assemblv Facility (MAF)	$1,500,000
1. Remediation Activities, Various Locations	1,500,000
I. Stennis Space Center (SSC)	*$3,750,000*
1. Remediation of Site 6 Contamination	1,750,000
2. Remediation of Site 11 Contamination	1,000,000
3. Remediation of Site 7 Contamination	1,000,000
J. Wallops Flight Facilitv (WFF)	$400,000
1. Remediation of Fire Training Area	400,000
K. White Sands Test Facilitv (WSTF)	$2,000,000
1. Groundwater Contamination Assessment and Remediation	2,000,000
L. Studies, Remedial Investigations, Feasibilitv Studies, Assessments, Designs. Related Engineering. and Remedial Sampling and Monitoring	$10,125,000
Total Environmental Compliance and Restoration	$40,000,000

FUTURE ESTIMATED PROGRAM FUNDING REQUIRED:

Approximately $40 million per year for the next few years **is** the current estimate for meeting the Environmental Compliance and Restoration Program requirements. This figure will become better defined as compliance/remediation studies are completed, and remediation activities are reviewed by Federal, state, and local regulators.

Inspector General

INSPECTOR GENERAL

FISCAL YEAR 1998 ESTIMATES

BUDGET SUMMARY

OFFICE OF INSPECTOR GENERAL

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1997	FY 1998	FY 1999
	(Thousands of Dollars)		
Personnel & related costs	15.119	16,900	18,500
Travel	753	800	900
Operation of installation..	899	600	600
Facilities services	(--)	(--)	(--)
Technical services	(679)	(300)	(300)
Management and Operations	(220)	(300)	(300)
Total..	16,771	18,300	20,000
Distribution of Program Amount by Installation			
Headquarters	16,771	18.300	20,000
Total..	16,771	18,300	20.000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1999 ESTIMATES

OFFICE OF INSPECTOR GENERAL

The NASA Office of Inspector General (OIG) budget request of $20.0 million for FY 1999 is based primarily on 210 Full-Time Equivalents (FTEs). The personnel and related cost of the 210 FTEs represents approximately 92 percent of the total OIG budget request. (we currently are staffed at a 198 FTE level). The increased FTE level of 210 will allow the OIG to continue building the Computer Crimes Program and other key financial audit programs (for example, full cost accounting, integrated financial management information systems, etc.). This is barely the minimal staffing level that will allow the OIG to perform its legislated mission. At the requested level, the OIG will: (1) provide assistance and work cooperatively with Agency management as it carries out NASA's programs and operations; (2) maintain a balanced audit program, including providing technical assistance and oversight of the audit of the Agency's financial statements as required by the Chief Financial Officers (CFO) Act; (3) concentrate investigative resources on procurement fraud and computer crime matters including emphasis on prevention initiatives; (4) work cooperatively with management by conducting inspections, assessments and reviews of issues identified by the OIG as well as those that are of concern to Agency management; and (5) deploy audit staff to timely provide feedback on NASA's re-engineering and streamlining initiatives. This budget level recognizes the fiscal constraints facing the Agency and the need for the OIG to provide quality products and services that are timely and meet our customers' needs. In light of increasing budget constraints, the Inspector General continues streamlining activities to increase the mission capability of the OIG staff. Initiatives include continued conversion of administrative overhead positions to program assistants and analysts responsible for assisting on direct mission activities of the audit, investigative, and inspection missions; staff reductions in the resources management division; and matrixing existing personnel and management analyst positions to support direct mission activities. In addition, the OIG continues to streamline and simplify communications and reporting channels, and improve computer and telecommunications capacities to further increase staff capabilities.

As NASA continues to downsize, establish new priorities, and modify its programs and operations within proposed budget constraints, efforts will continue within the OIG to concentrate staff resources on those programs and operations identified as the most critical and vulnerable to fraud and abuse. Throughout this process, the OIG is increasing its cooperation with NASA management while assuring that the OIG's statutory independence is maintained. The OIG will continue to set priorities based on funding levels, program needs, Congressional and Administration concerns, and the results of OIG research and findings.

The OIG's missions include conducting independent audits, investigating, and inspecting/assessing/reviewing NASA's programs and operations while working as cooperatively as feasible with NASA's management and program managers. Audits will be prioritized and selected to evaluate programmatic, operational and financial management concerns, information technology systems and operations, and internal control vulnerabilities. The investigations program, with its computer crimes capability, will continue to place greater emphasis on the investigation of computer intrusions and frauds in which the computer was used as an instrument of the crime. The remaining investigation's program will focus on complex procurement and other fraud matters including fraud against the Government by contractor and Government employees, product substitution, and other procurement irregularities. Each investigative matter will be approached on a programmatic, priority basis to identify preventive initiatives. Inspections, assessments, and reviews will be conducted which support: management's interests and concerns in achieving NASA's programmatic objectives more efficiently and effectively; issues of Congressional concern: matters of high Agency vulnerability; and administrative inquiries related to unethical and improper conduct, waste and mismanagement.

OBJECTIVES AND STATUS

This request represents the OIG resources (FTEs) needed at NASA Headquarters and field offices to fulfill the OIG mission. Recognizing that every identified audit, investigations, inspections, assessments, and other workload reviews significantly exceed the available resources, continuous adjustments of priorities will be necessary to ensure: a balanced coverage of NASA's programs and operations is maintained: all critical and sensitive matters are promptly evaluated and investigated: and all OIG customers receive timely, accurate, and complete responses.

The OIG uses a formal, comprehensive process to identify, review, prioritize, and select the audits, inspections, evaluations, and reviews that are to be performed. The OIG assignments are derived from: (1) monitoring NASA's evolving initiatives in downsizing, re-engineering, commercialization, and privatization to determine opportunities for efficiencies and vulnerabilities: (2) selecting audits and reviews using a structured approach encompassing NASA's programs and operations and an external universe comprised of NASA's prime contractors, their subcontractors, and grantees; and (3) addressing issues required by laws and internal regulations. The audits and reviews identified from these sources are prioritized and compared to available resources and published in the annual OIG work plan. The OIG will continue its NASA-wide program-oriented reviews to obtain greater visibility and awareness of issues related to NASA's major programs and initiatives.

Agency vulnerabilities are determined by taking into consideration the following: (1) whether program and project objectives are accomplished in the most cost effective manner and comply with safety and mission quality initiatives: (2) whether management's actions are sufficient to correct internal control weaknesses reported under the Federal Manager's Financial Integrity Act (FMFIA); (3) whether NASA's annual expenditure on information technology is providing expected programmatic and financial information needed to make sound decisions (NASA is one of the top ranked civilian agency in information technology spending); (4) whether improvements are implemented in financial management systems, practices, controls, and information; (5) whether the audit follow-up system is effective in enabling management to maintain the status of corrective actions: and (6) whether Agency-wide corrective actions addressing environmental concerns are adequate. Each of the identified vulnerabilities are evaluated, prioritized, and included in our plans for further action.

Further, Agency program and project changes, growth, delays, and termination increase the need for OIG oversight of contractor/subcontractor/grantee cost, schedule, and performance effectiveness. NASA's continued reliance on contractors and grantees (about 90 percent of the Agency's total obligations are for procurement) will require increasing direct OIG involvement and oversight of Defense Contract Audit Agency (DCAA) and Health and Human Services (HHS) OIG audits of NASA contractors and grantees to ensure effective contract and grant execution and administration. During FY 1997, NASA was billed approximately $16.8 million for contract audit services.

MEASURES OF PERFORMANCE

WORKLOAD	FY 1997	FY 1998	FY 1999
Office Staff Ceiling			
Full-Time Equivalents	187	198	210
Investigations			
Cases pending beginning of year	328	257	207
Opened during year	185	200	230
Closed during year	256	250	215
Cases pending end of year	257	207	222
Audits			
Audits pending beginning of year	41	52	53
Opened during year	60*	58*	64
Closed during year	49	57	60
Audits pending end of year	52	53	57
Inspections & Assessments (IA) and Partnerships & Alliances (PA)			
IA Administrative Investigations pending beginning of year	17	40	50
Opened during year	73	80	70
Closed during year	50	70	75
IA Administrative Investigations pending end of year	40	50	45
IA and PA Reviews pending beginning of year	11	22	25
Opened during year	24	20	35
Closed during year	13	17	37
IA and PA Reviews pending end of year	22	25	23

*Emphasis on programmatic audits

Durihg FY 1999, the OIG will continue to focus attention and provide support to program managers on issues relating to: Earth Science (formerly Mission to Planet Earth), Communications, Human Exploration and Development of Space, Space Technology, Information Technology, Aeronautics, and Space Transportation. The functional areas we will evaluate include Procurement and Contract Administration, Technology Transfer, Financial Management, Information Resources Management, Information Systems and Communications Security, and Facilities and Equipment. The OIG's Information Technology Audit Group will continue to focus on the security and integrity of NASA's major information systems and operations. Financial management's significance increased with the passage of the CFO Act. Pursuant to the Inspector General Act, we have selected independent auditors to render an opinion on the Agency's annual financial statements, its internal control structure, and its compliance with laws and regulations. Our financial audits will concentrate on accounting controls, information systems, and required performance measurements.

The OIG will continue to monitor and assess NASA's high risk areas, material weaknesses, and areas of significant concern to ensure that corrective actions are implemented in a timely manner. Areas of emphasis will include: financial systems-accounting; procurement and environmental programs; NASA information technology resources and security; institutional contracting practices; contract management; contractor cost reporting; allotment and budgetary controls; and financial reporting/general ledger. The defined audit and review workload far exceed available staff. Continuous adjustment of priorities will be necessary in order to provide balanced coverage of programs and operations most vulnerable to abuse and mismanagement.

The OIG investigative workload continues to exceed the availability of investigative resources. The FY 1999 investigative staffing level will require OIG management to effectively manage the complex workload of investigative criminal and civil fraud matters. The establishment of the Computer Crimes Division allows the OIG to investigate unauthorized intrusions into and compromises of NASA and contractor computer systems, as well as assessing vulnerability to information terrorism. The number of complex procurement fraud cases also remains high. Such cases take longer to resolve and are resource intensive, thereby limiting our flexibility to expand the program. A Proactive Program Fraud Division was established to focus on program fraud areas identified by our audits as highly vulnerable to fraud. We are working with management to help us address all substantive allegations received, to refer more routine administrative matters to them for their resolution, and request that they keep the OIG advised of the action taken. We are also referring more serious administrative matters to the OIG Inspections and Assessments (I&A) staff for review. By referring matters to Agency managers and the I&A staff to resolve, we can reserve our investigative resources to address the more serious fraud allegations made to the OIG.

In summary, the OIG will collaborate with Agency management to address issues of joint concern; to improve scope, timeliness, and thoroughness of its oversight of NASA programs and operations; identify preventive measures; and enhance its capability to assist NASA management to efficiently and effectively achieve program and project goals and objectives.

BASIS OF FY 1999 FUNDI IREMENT

PERSONNEL AND RELATED COSTS

	FY 1997	FY 1998	FY 1999
		[Thousands of Dollars)	
Compensation and Benefits	**14.481**	**16.395**	**17.905**
Compensation	12.334	13.791	15.040
(Full-time permanent)	(12.108)	(13.400)	(14.670)
(Other than full-time permanent)	(55)	(185)	(120)
(Overtime & other compensation)	(171)	(206)	(250)
Benefits	2.547	2.604	2.865
Supporting Costs	**238**	**505**	**595**
Transfer of personnel	120	300	360
Personnel training	103	190	220
OPM Services	15	15	15
Total	**15.119**	**16,900**	**18.500**

	FY 1997	FY 1998	FY 1999
		(Full-Time Equivalents)	
Full-time permanent	182	196	208
Other controlled FTEs	5	2	2
Total	187	198	210

These estimates provide the resources required for full staffing of NASA OIG's Information Technology Audit and Computer Crimes Divisions.

TRAVEL

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Travel	753	800	900

Travel funding is required to carry out audit, investigation, inspection and assessment, partnerships and alliances, and management duties. Our budget allows for increases in per diem, airline costs, and workloads. We anticipate increased travel by our information technology audit and computer crimes teams. *Also,* in order to respond to NASA's changing priorities (and implementation of its centers of excellence and commercialization efforts), increased travel funds will be required to deploy staff located at field offices remote from the site where audit and investigation activities occur.

OPERATION OF INSTALLATION

	FY 1997	FY 1998	FY 1999
		(Thousands of Dollars)	
Technical Services...	679	300	300
Management and Operations..	220	300	300
Total...	899	600	600

Operation of Installation provides a broad range of services and equipment in support of the Inspector General's activities

The Technical Services estimate provides for all equipment, including purchase, maintenance, programming and operations of unique automated data processing (ADP) equipment. NASA provides common services items such as office space, communications, supplies, and printing and reproduction at no charge to the Office of Inspector General. The funding for Technical Services will cover the cost of providing unique ADP upgrades, and replacement of unique equipment that has become outdated or unserviceable. As funding permits, in FY 1998 we will continue to improve our PC-based wide-area network and management information system.

The Management and Operations category includes miscellaneous expenses within the Office of Inspector General, i.e., GSA cars, the Inspector General's confidential fund, miscellaneous contracts, and supplies not provided by NASA.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

OFFICE OF INSPECTOR GENERAL

For necessary expenses of the Office of Inspector General in carrying out the Inspector General Act of 1978, as amended, [$18,300,000] *$20,000,000*. *(Departments of Veterans Affairs and **Housing** and Urban Development, and Independent Agencies Appropriations Act, 1998.)*

FY 1998 Changes

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CHANGES FROM FY 1998 BUDGET ESTIMATE TO FY 1998 CURRENT ESTIMATE

(Dollars in Millions)

HUMAN SPACE FLIGHT

The funding level for the Human Space Flight appropriation of $5,679.5 million reflects an increase of $353.0 million above the FY 1998 budget request. The net increase is the result of an additional $180 million provided in the FY 1998 VA-HUD-Independent Agencies Appropriations Act (P.L. 105-65), and the proposed addition of $173 million to the Human Space Flight appropriation. The Administration will propose transfer authority of $128 million from the Science, Aeronautics and Technology, $45 million from the Mission Support appropriation, and the reallocation of $27 million from within the Human Space Flight appropriation, for a total funding increase of $200 million for Space Station. The NASA Operating Plan submitted in January 1998, reflects the application of the additional $180 niillion. The Administration will include a request for the transfer authority as part of its FY 1998 Budget Supplemental. The distribution of the total increase is included below.

	FY 1998			
	BUDGET ESTIMATE	AFPROP TRANSFER	OTHER CHANGES	CURRENT ESTIMATE
Space Station	**2,121.3**	**200.0**	**180.0**	**2,501.3**
Development	1,386.1	200.0	203.8	1,789.9
Operations	490.1			490.1
Research program	245.1		-23.8	221.3

CHANGE FROM FY 1998 BUDGET ESTIMATE

Funding for Space Station is increased $380 million above the FY 1998 budget request. This reflects the prospective transfer authority of $173 million, the reallocation of $27 million from within the Human Space Flight appropriation, and the addition of $180 million, as provided for in P.L. 105-65.

The FY 1998 funding plan for the International Space Station (ISS) continues to be a critical issue. When the FY 1998 appropriation was enacted, the additional funding provided for ISS and related activities amounted to $230 million. This is comprised of the above-noted $180 million, plus the reallocation of $50 million within the Human Space Flight appropriation from the Space Shuttle to the ISS directed in House Report 105-297. This represented a partial accommodation of NASA's identified additional FY 1998 requirement of $430 million for the ISS and Russian Program Assurance programs.

NASA is taking no action at this time that would result in a slip in the program schedule as a result of the $200 million shortfall. In recognition of the need to address this shortfall, NASA plans to reallocate $27 million within Human Space Flight and seek transfer authority for the remaining $173 million. The Administration will be requesting the transfer authority as part of its FY 1998 budget supplemental. Of the $173 million to be sought in transfer authority, NASA plans to transfer $73 million upon enactment by Congress with the remaining $100 million provided later as warranted. The FY 1998 budget estimates in this document assume the full $173 million has been transferred along with the $27 million reallocation.

Within this funding level, direction to ISS program management is consistent with direction in P.L. 105-65 that no more than $1.5 billion shall be available prior to March 31, 1998.

	FY 1998			
	BUDGET ESTIMATE	APPROP TRANSFER	OTHER CHANGES	CURRENT ESTIMATE
U.S/Russian Cooperation and Program Assurance ..	**0.0**		***50.0***	***50.0***

The increase of $50 million above the FY 1998 budget request reflects the reallocation of funds from Space Shuttle as reflected in the FY 1998 Operating Plan, and is consistent with direction included in House Report 105-297. This additional funding, as well as available uncosted budget authority from FY 1997, will enable completion of the development of the Interim Control Module (ICM) and modifications of the functional cargo block (FGB) to add enhanced attitude and control capabilities to the International Space Station. These efforts were initiated in FY 1997 in response to the delay in availability of the Russian service module (SM) from May 1998, to December 1998, which necessitated a contingency plan in the event of further Russian delays or shortfalls. Because of budget limitations, serious consideration was given to the consequences of terminating the ICM development, but it was determined that the ICM remains a prudent investment by the United States Government.

	FY 1998 BUDGET ESTIMATE	APPROP TRANSFER	OTHER CHANGES	CURRENT ESTIMATE
Space shuttle	**2,977.8**	**-5.0**	**-50.0**	**2,922.8**
Shuttle Operations	2,494.4	-5.0	-120.0	2,369.4
Orbiter and integration	463.1	-5.0	44.8	502.9
Propulsion	1,136.7		-75.1	1,061.8
Mission and Launch Operations	894.4		-89.7	804.7
Safety and performance upgrades	483.4		70.0	553.4
Orbiter Improvements	137.3		95.2	232.5
Propulsion Upgrades	247.0		-71.0	176.0
Flight operations and launch site equipment	92.3		45.8	138.1
Construction of facilities	6.8			6.8

CHANGE FROM FY 1998 BUDGET ESTIMATE

Total funding for Space Shuttle is reduced $55 million, which has been reallocated to Space Station. Funding for Shuttle Operations is reduced $125 million. This reflects reallocation of $50 million within Human Space Flight from Space Shuttle to Space Station as identified in House Report 105-297, reallocation of $70 million to Safety and Performance Upgrades, and an additional $5.0 million reallocation to Space Station to assist in meeting the remaining FY 1998 funding shortfall.

Within Shuttle Operations, this funding reduction is accommodated based on results from the continuing restructuring efficiencies and flight rate changes. Funding for Orbiter and Integration is increased a net of $39.8 million. This increase reflects additional consolidation of Space Shuttle activities within the Space Flight Operations Contract (SFOC), primarily the Solid Rocket Booster effort. This represents the first major Phase II contract to be consolidated, with 12 operational contracts having been previously consolidated in FY 1997. In addition, $5.0 million is reallocated to the International Space Station to assist in meeting the shortfall of $200 million in FY 1998. Funding for Propulsion is reduced $75.1 million reflecting the following: (1) prior stockpiling of critical materials (RSRM); (2) rephased and revised SSME-Alternate Turbopump (ATP) hardware requirements; and, (3) partial-year SRB transfer to SFOC. Funding for Mission and Launch Operations is reduced $89.7 million reflecting a decrease due to anticipated achievement of mission and ground operations efficiencies, due in large part to restructuring, consolidation and flight rate changes.

This reduction in Mission and Launch Operations, as noted, has resulted from achieving planned efficiencies and unutilized reserves, which do not directly relate to reductions in scope or contractor/civil service workforce levels. Under the terms of the overall Space Shuttle restructuring effort, a major portion of which was the consolidated prime contract under U. S. Alliance, workforce levels on all Shuttle contracts are being reduced. This consolidation is in direct response to the recommendations of the NASA Zero Base Review in 1995 and supports a key NASA strategic goal of reducing the cost of access to space. The U. S. Alliance contract incentivizes efficiencies that do not compromise safety. Reducing the cost of operating and maintaining the Space Shuttle fleet, while maintaining safe operations, is and will continue to be a major priority of the program.

Total funding for Safety & Performance Upgrades reflects a net increase of $70 million. This reflects an increase of $95.2 million to Orbiter Improvements and an increase of $45.8 million in Flight Operations & Launch Site Equipment Upgrades for continuation of Shuttle upgrades begun in FY 1997. These increases are offset by a reduction of $71 million for Propulsion Upgrades, resulting from completion of the Super Light Weight Tank development program, a rephased Alternate Turbopump program.

This reallocation of funding between Shuttle Operations and Safely and Performance Upgrades is consistent with the plan presented in the FY 1998 budget to pursue a program of upgrades to assure Shuttle availability through 2012. Total funding for Shuttle Upgrades in FY 1998 is $75 million. Available uncosted funding which are the result of efficiencies and unutilized program reserves are being reallocated to fund such upgrades as the Checkout and Launch Control System at KSC. the Micrometeoroid/Orbital Debris protection system for the Orbiter, and the Global Positioning System adaptation for Shuttle navigation. Other upgrade candidates are actively being studied for near-term development to significantly improve Shuttle safety margins, performance or reliability/efficiency.

	FY 1998			
	BUDGET ESTIMATE	APPROP TRANSFER	OTHER CHANGES	CURRENT ESTIMATE
Payload and utilization operations	**227.4**	**-22.0**	***0.0***	**205.4**
Spacelab	14.2		-2.3	11.9
Payload Processing and Support	51.6	- 10.0	2.3	43.9
Advanced projects	58.7	-12.0		46.7
Engineering and technical base	102.9			102.9

CHANGE FROM FY 1998 BUDGET ESTIMATE

Funding for Payload and Utilization Operations is reduced a total of $22 million. As reflected in the FY 1998 Operating Plan, $2.3 million has been reallocated from the Spacelab program to Payload Processing and Support. This reallocation reflects the transfer of responsibility for payload carrier storage, unique hardware and ground support equipment, facility preparation and recurring costs, etc., as the Spacelab program prepares to close out following the Neurolab mission in mid-FY 1998.

Funding for Payload and Utilization Operations is reduced $22.0 million, reflecting the reallocation of funding within Hunian Space Flight to assist in meeting the additional FY 1998 funding requirements for the Space Station. Funding for Payload Processing is reduced by $10.0 million (for a total net reduction of $7.7 million), and funding for Advanced Projects is reduced by $12.0 million. Within Advanced Projects, $5.0 million is reallocated internally to provide for initial funding for Crew Return Vehicle definition studies.

SCIENCE, AERONAUTICS AND TECHNOLOGY

The funding level for the Science, Aeronautics and Technology appropriation of $5,552.0 million reflects a reduction of $128.0 million from the FY 1998 request. The distribution of this reduction, and other proposed funding reallocations, are included below.

	FY 1998			
	BUDGET ESTIMATE	APPROP TRANSFER	OTHER CHANGES	CURRENT ESTIMATE
Space science	**2,043.8**	**-50.0**	**-10.0**	**1983.8**
Advanced x-ray astrophysics facility	92.2		3.6	95.8
Space Infrared Telescope Facility	81.4		-26.0	55.4
Relativity mission development	45.6		11.7	57.3
Cassini	9.0		-9.0	0.0
TIMED	48.2		4.5	52.7
Payload and instrument development	12.3		5.7	18.0
Explorers	142.7		-29.2	113.5
Discovery	106.5		-30.0	76.5
Mars Surveyor	139.7		5.5	145.2
New Millennium	75.7		-36.0	39.7
Advanced Space Technology	151.2		-24.9	126.3
Mission operations and data analysis	507.4	-11.9	33.0	528.5
Supporting Research and technology	311.2	-38.1	102.6	375.7
Suborbital program	84.4		-1.1	83.3
Launch services	236.3		-20.4	215.9

CHANGE FROM FY 1998 BUDGET ESTIMATE

Total funding for Space Science is reduced $60 million. This reduction is comprised of a net reduction of $10 million, as reflected in the FY 1998 Operating Plan, and the transfer of $50 million to the Human Space Flight appropriation for the Space Station. This funding is made available by changes in the processes for awarding research grants. These changes will allow reductions in budget authority in the Research and Analysis and Data Analysis programs, with no effect on the level of activity in those programs. As a result, Space Science program commitments, products, and scheduled events can be met within the reduced funding amount.

Funding for Advanced X-Ray Astrophysics Facility (AXAF) development is increased by $3.6 million. These funds were reallocated from AXAF Mission Operations and Data Analysis (MO&DA) reserves. This funding is required to mitigate the schedule risk associated with delays in the integration and test of AXAF. These delays are likely to result in a launch later than the planned date of August 1998.

Space Infrared Telescope Facility (SIRTF) development is reduced by a net of $26 million. However, the total FY 1998 SIRTF funding is increased $14 million to allow the SIRTF program to initiate long-lead procurements which is intended to minimize programmatic and schedule risks associated with the SIRTF mission. The reduction in SIRTF development reflects reallocation of $40 million to SIRTF Advanced Technology Development (ATD) to fund the completion of Phase B activities, which had always been planned to be finished on March 30, 1998. Funding will be rephased in outyear budgets, resulting in no change to the total SIRTF cost.

Funding for the Relativity Mission (GP-B) is increased $11.7 million to address a problem with the axial lock between the dewar and the probe. The correction for this problem has been identified and tested. Funding for this increase is made available by rephasing the GP-B launch vehicle and future Explorer missions. GP-B will offset this increase within the outyear GP-B budget, resulting in no net increase to the total life cycle cost of the mission.

Cassini development is reduced $9 million, reflecting the excellent cost, technical and schedule performance on this program, which was launched successfully on October 15, 1997.

Funding for the Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED) development is increased $4.5 million. The increase will support long-lead procurements to reduce schedule risk in meeting the May 2000 launch date. The resources have been made available by rephasing Explorers development. There will be no increase in the life-cycle cost of TIMED, as the funds will be rephased between the TIMED and Explorers projects in the outyears.

Payload and Instrument Development is increased by $5.7 million. Of this increase, $3.3 million has been added to support U.S. participation in the reflight of European Space Agency's (ESA) Cluster mission. The original Cluster payload (including the U.S. contribution) was lost as a result of the Ariane-V launch failure on June 4, 1996. The total estimated U.S. share of the cost of the Cluster replacement is $9.3 million through FY 2000. $1.2 million of the increase in Payload and Instrument Development supports U.S. participation in ESA's Planck cosmic background survey mission. Total U.S. development funding for Planck is anticipated to be $7 million through 2003. The remaining $1.2 million increase in Payload and Instrument Development funds cost increases resulting from technical problems in the U.S. portion of ESA's X-ray Multi-mirror Mission (XMM).

Funding for the Explorers development program is reduced by $29.2 million. Of this reduction, $25.5 million is reallocated to other programs, as a result of savings in the Advanced Composition Explorer (ACE) mission (launched in August 1997), reduced costs for future Small Explorers (SMEX) and rephasing of other future Explorers. The SMEX reduction is based on the recent selection of three SMEX missions for development: the High Energy Solar Spectroscopic Imager (HESSI); the Galaxy Evolution Explorer (GALEX) and the Two Wide-Angle Neutral Atom Spectrometers (TWINS) payload. The remaining $3.7 million reduction reflects reassignment of Explorer Technology activity and associated funding to Supporting Research and Technology as part of the consolidation of technology activities. In addition to the reductions, Space Science has reallocated $3.7 million to support development of a replacement for the High Energy Transient Explorer (HETE-II) within existing funds. The original HETE mission was lost due to a launch failure in November 1996.

Funding for the Discovery program is reduced by $30 million, due to revised development and funding requirements for the two new Discovery missions selected in October 1997. One of the new missions, Genesis, will enter the development phase in FY 1998; to accommodate this schedule, $20.3 million is being reallocated from the future Discovery budget to Genesis development.

Funding for Mars Surveyor is increased by a net of $5.5 million. The increase reflects reallocation of $15 million in funding and activity from Exploration Technology within Supporting Research and Technology to Mars Surveyor. This activity is directly applicable to future Mars missions. An unrelated reduction of $9.5 million is accommodated by eliminating unallocated reserves. Within the Mars Surveyor program, funding is included to initiate the Mars 2001 mission, to meet the science objectives of the Space Science and Human Exploration and Development of Space Enterprises.

New Millennium funding is reduced by a net of $36 million. Funding for Outer Planetary Technology ($25 million), Advanced Radioisotope Thermal Generators ($10 million) and the Center for Integrated Space Microsystems ($10 million) is reallocated from New Millennium to Supporting Research and Technology as **part** of the technology consolidation. This reduction is offset by the reallocation of $9 million previously budgeted within Advanced Space Technology Development to New Millennium.

Spacecraft Systems Technology Development has been renamed Advanced Space Technology Development. This reallocation initiated by the redistribution of responsibilities of the former Office of Space Access and Technology in 1996 is complete. Funding for Advanced Space Technology Development is decreased by a total of $24.9 million. Of this amount, $15.9 million in funding and activity is reassigned to Supporting Research and Technology as part of the technology consolidation. This funding directly supports Space Science-unique activities in Origins and other Space Science Advanced Technology Development. An additional $9 million in funding for work on current New Millennium deep space missions is reassigned to New Millennium. Also, within Advanced Space Technology, $2 million is identified for continued analysis of technologies and systems concepts identified in NASA's 1996 "Fresh Look" study of space solar power. This study is intended to produce more mature understanding of requirements for space solar power technology maturation, estimated costs, and potential timetables.

Funding for Mission Operations and Data Analysis is increased by a total of ***$33*** million. The International Solar Terrestrial Physics program (ISTP) is increased by $26.4 million to initiate the ISTP Solar Maximum missions and keep them operational through the end of FY 1999. Space Science has met the challenge of funding this important international collaborative effort within available Enterprise resources. Near Earth Asteroid Rendezvous (NEAR) funding is increased by $1.5 million, paying back part of the prior year reductions and allowing FY 1998 activities to be completed with minimal carryover of resources. Funding for Hubble Space Telescope is increased by a net of $10.4 million. Funding for Hubble Operations and Servicing is increased by $16.6 million to support additional preparations for the third servicing mission, scheduled for November 1999. This work involves multi-layer insulation repair, aft shroud thermal correction, development of a cryo-cooler to extend the life of the NICMOS instrument, and the flight of a Shuttle experiment to test the new cryo-cooler and new electronic components in the space environment. The increase is partially offset by $6.2 million in Hubble Data Analysis funds set aside for transfer to Hubble Operations and Servicing several years ago. The reduction in Data Analysis will have no impact on the Hubble science program plans. The Mars Pathfinder project is being shut down after greatly exceeding mission goals, enabling a $1.4 million reduction with no impact. Finally, MO&DA reserves are being reduced for AXAF (-$3.6 million).

Consistent with Congressional direction, Space Science Technology efforts are being restructured and consolidated. The first step in the restructuring resulted in an increase of $102.6 million to the existing Supporting Research and Technology budget element. $40 million is reallocated from SIRTF Development to SIRTF pre-development activities, in recognition that development had not been planned to start until April 1998. A total of $45 million is reallocated from New Millennium to a focused technology budget element: $25 million in Outer Planetary Technology; $10 million for Advanced Radioisotope Thermal Generators; and, $10 million for the Center for Integrated Space Microsystems. $15.9 million is reallocated in from Advanced Space Technology for Origins and other technology development. Funding totaling $3.7 million for Explorer technology development activities has been reallocated to Supporting Research and Technology. Information Systems uncosted balances have been reduced by $2 million. *Also* in accordance with direction in House Report 105-297, Solar-B is funded at $3 million and Solar-Stereo is funded at $3 million within the Supporting Research and Technology budget.

In the second step of the technology budget restructuring, the Advanced Space Technology and New Millennium programs were brought into the Supporting Research and Technology budget line. The resulting Space Science Enterprise technology program is organized into three elements:

1. A **Core Program** of research supporting mission-specific technologies for Space Science and cross-cutting spacecraft and robotics technologies for multiple NASA Enterprises. The Core Program supports enabling technologies for the next generation of high performance and cost-effective Space Science missions. ***An*** aggressive technology development approach is used that allows all major technological hurdles to be cleared prior to a science mission's development phase. Retiring technological risk early in the mission design cycle, while emphasizing innovation to reach previously unattainable goals in mass reduction and performance, are key to the success of many of the missions planned for the next century.

   Cross-Enterprise technology development, formerly the Advanced Space Technology budget, is generally multi-mission in nature and tends to focus on the earlier stages of the technology life-cycle. Emphasis is on basic research into physical principles, formulation of applications concepts, and component-level performance evaluation. Where appropriate, these developments may extend all the way to subsystem-level development and test for nearer-term missions. These cross-cutting developments are the foundation for most new spacecraft, robotics, and information technologies eventually flown on NASA missions.

   This core program is approximately $200 million in FY 1998, of which the majority will be competitively awarded. The amount of the work to be competed depends on the nature of the efforts, and both the Space Science and Cross-Enterprise core programs fund three general types of activities: support for internal critical activities and Agency core competencies; partnerships with industry and other Government agencies; and discretionary technology funding for broad competition. Given the multiyear nature of the these technology activities, it must be recognized that much of the funding being consolidated in this budget represents the continuation of technology efforts for which competitive decisions were made in prior years. Consequently, only a fraction of the funding identified as "competable" will be actually available for new competition in FY 1998. That portion of ATD funding that is "competable" will be broadly competed through Announcements of Opportunity and/or Requests for Proposals.

2. Several **Focused Programs,** totaling about $170 million in FY 1998, are dedicated to specific high-priority technology areas. These can encompass developments from basic research all the way to infusion into science missions. They are driven by the needs of Space Science, but other Enterprises are likely to benefit from them. Focused Programs include the mission studies which effectively form the front end of the overall technology development program. Scientists work collaboralively with technologists and mission designers to develop the most effective alignment of technology development programs with future missions. This collaboration enables intelligent technology investment decisions by fully exploring the design and cost trade space. These studies will utilize new techniques for integrated design and rapid prototyping to ensure that realistic, implementable decisions are reached.

There are presently four Focused Programs:

Advanced Deep Space System Technology. This program will develop, integrate, and test revolutionary technologies for solar system exploration. Emphasis **will** be on micro-avionics. autonomy, computing technologies, arid advanced power systems. Along with other technologies, these will be integrated as advanced engineering-model flight systems to form the basis for the new generation of survivable, highly capable micro-spacecraft.

Astronomical Search for Origins Technology. This program will develop critical technologies for studies of the early Universe and of extra-solar planetary systems. Included are large lightweight deployable structures, precision metrology, optical delay lines, and other technologies for space-based interferometry. Also included are technologies such as inflatable structures and large lightweight optics required by many proposed missions and concepts.

Structure and Evolution of the Universe Technology. This program will provide the technologies required for missions focused on understanding how the structure of our Universe emerged from the Big Bang, how the Universe is continuing to evolve, and what will be the fate of the Universe. Examples of technology in this area include sensors, detectors, and other instruments, as well as cryocoolers and other instrument support systems.

Sun-Earth Connections Technology. This program will develop the technologies needed for missions focused on understanding long-term and short-term solar variability, and how solar processes affect the Earth. Technologies supported in this area include thermal shielding, integrated fields and particles sensors, and a high temperature solar array.

3. A **Flight Validation Program** -- formerly the "New Millennium Program" (approximately $40 million in FY 1998) -- conipletes the technology development process by validating technologies in space. New Millennium missions are driven by needs for technology validation, but are also designed to return high priority science data within cost and mission constraints. Industry-government partnerships are used to identify technology candidates, complete their development, and select them for flight. Through this process, high-value technologies are made available for use in the Space Science program without imposing undue cost and risk on individual science missions. The New Millennium Program is funded by both the Space Science Enterprise and the Mission to Planet Earth Enterprise.

The Research and Analysis program remains a separate part of the Supporting Research and Technology budget element. However, all technology development activities formerly funded within the R&A program ($12 million per year) have been moved to the technology Core Program.

The Suborbital program is reduced by $1.1 million as a result of delays in awarding the new Sounding Rocket Operations contract These funds will be restored in later years.

The Expendable Launch Vehicle budget is reduced by $20.4 million. This reduction reflects the reallocation of $8 million to the Relativity Mission, which will be repaid in the outyears, savings of $10 million from the Cassini mission, rephasing of $7.4 million to 1999 and an increase of $5 million to fund the launch of HETE-II.

	FY 1998			
	BUDGET ESTIMATE	APPROP TRANSFER	OTHER CHANGES	CURRENT ESTIMATE
Life and Microgravity Sciences and Applications	**214.2**		***0.0***	**214.2**
Life Sciences	85.5		3.0	88.5
Research and analysis......................................	50.0		3.7	53.7
(Construction of Facilities)	[2.0]		[0.2]	[2.2]
Flight program	35.5		-0.7	34.8
Microgravity research	101.4		-1.0	100.4
Research and analysis.......................................	36.5		-5.7	30.8
Flight program	64.9		4.7	69.6
Aerospace medicine	7.5			7.5
Shuttle/spacelab payload mission management and integration	6.9		-2.0	4.9
Space Product Development	12.9			12.9

CHANGE FROM FY 1998 BUDGET ESTIMATE

Funding for Life and Microgravity Sciences and Applications activities is unchanged from the requested level of $214.2 million. Funding for Life Sciences is increased $3 million; within this total, $5.5 million is included in Life Sciences/R&A for NASA's space radiation health program as directed in House Report 105-297. To offset this direction, total funding for Life Sciences/R&A is increased $3.7 million. This reflects the reallocation of $1 million from Microgravity/R&A, $2 million from Shuttle/Spacelab Payload Mission Management and Integration, and $.7 million from Life Sciences/Flight Programs. These reallocations are accommodated from available uncosted funds. Within Microgravity Research, $4.7 million is reallocated from R&A to Flight Programs to support cooperative activities with the National Institutes of Health.

	FY 1998			
	BUDGET ESTIMATE	APPROP TRANSFER	OTHER CHANGES	CURRENT ESTIMATE
Earth Science	**1,417.3**	**-50.0**	**0.0**	**1,367.3**
Earth observing system	679.7		24.9	704.6
Earth observing system data information system..	244.7		-34.8	209.9
Earth probes	40.7		7.9	48.6
Applied research and data analysis	325.3	-50.0	89.1	364.4
Launch services	121.9		-87.1	34.8
GLOBE	5.0			5.0

CHANGE FROM FY 1998 BUDGET ESTIMATE

Total funding for Earth Science is reduced $50 million. This reduction is part of the transfer authority to be proposed by the Administration from the Science, Aeronautics and Technology appropriation to the Human Space Flight appropriation for the Space Station. This funding reduction is applied to Applied Research and Data Analysis, and is accommodated by applying available uncosted funds. All Earth Science program commitments, products, and scheduled events can be met within the reduced funding level.

The Earth Observing System (EOS) budget is increased by $24.9 million, from $679.7 million to $704.6 million. Within this total, $59.3 million has been reallocated from Launch Services to EOS to join the costs of mission development and launch services. An additional $9.5 million is reallocated from available Launch Services uncosted balances to accommodate funding requirements for continued development of the "QuikScat" mission. After a review of the EOS PM-1 program progress and funding plans, we have determined that $30 million can be reallocated from EOS-PM uncosted balances to Applied Research and Data Analysis/Mission Operations. In addition, $9 million is reallocated from available EOS-PM uncosted balances to increase funding for Research and Analysis as recommended by the Biennial Review. The remaining reduction of $4.9 million is the result of several reallocations. $4 million is reallocated to the Earth Observers portion of the EOS technology infusion effort from Launch Services. $2.5 million is reallocated to the Special Spacecraft budget for Earth Sciences Outreach. An additional $6 million is reallocated from the Special Spacecraft budget to the Mission Science budget within Applied Research and for the mission science teams. $1.9 million is reallocated to the Earth Probes budget for the Total Ozone Mapping Spectrometer (TOMS) budget to accommodate the long-standing commitment on the Russian contract. $.9 million is reallocated to the Tropical Rainfall Measuring Mission (TRMM) due the launch delay. $.6 million is reallocated to the Airborne Science and Applications program to complete the consolidation of Earth Science aircraft operations at the Dryden Flight Research Center. $2 million is reallocated from available uncosted funds in the Algorithm program to Research and Analysis for consortia to develop regional applications using EOS data.

The funding for "QuikScat" in this Operating Plan totals $34.5 million of which $20.6 million is from EOS-PM and $4.4 million is from EOS algorithms, in addition to $9.5 million from Launch Services. The "QuikScat" mission will fill the gap of the ocean-wind data created by the loss of the NASA Scatterometer on the Japanese Advanced Earth Observing Satellite (ADEOS) spacecraft, which ceased on June 30, 1997. "QuikScat" is planned for launch in November 1998, reducing the data gap by about one-half.

Within EOS, $5.0 million is reallocated from EOS-PM to Special Spacecraft to accommodate funding for the Lightning Mapper sensor consistent with direction in House Report 105-297. Also funding for the second series of EOS-AM and PM flights has been consolidated as EOS follow-on for mission planning.

Funding for EOS Data Information System (EOSDIS) is reduced by $34.8 million, from $244.7 million to $209.9 million. This reduction will not result in program disruption, and is derived from a reduction in available uncosted funding and minor adjustments in reserves. The reduction in EOSDIS is reallocated as follows: $8.4 million is reallocated to Research and Analysis in response to the Biennial Review recommendations; $12.1 million is reallocated to Mission Operations for the Alaska Synthetic Aperture Radar *(SAR)* facility consolidation and to continue satellite laser ranging; $2.2 million is reallocated to commercial remote sensing: $.6 million is reallocated to TOMS: and $5.5 million is reallocated to mission science teams as part of the science consolidation. $6 million is reallocated to Research and Analysis for consortia to develop regional applications using EOS data.

Funding for Earth Probes is increased by $7.9 million, from $40.7 million to $48.6 million. Funding for TOMS is increased $2.5 million to accommodate the long standing commitment on the Russian contract. Funding for TRMM is increased by $.9 million to address additional costs resulting from the launch delay from August 1997 to November 1997. Funding for ESSP is increased $8.5 million due to the transfer of the launch services. Within Earth Probes, an additional $2 million is being transferred to the experiments of opportunity from Lewis and Clark operations as a result of the recent loss of Lewis. $4 million is reallocated from ESSP to Research and Analysis for consortia to develop regional applications using EOS data.

Funding for Applied Research and Data Analysis is increased a net of $89.1 million, from $325.3 million to $364.4 million. Of this increase, $17.4 million is for research and analysis to meet the biennial review recommendations. This funding is transferred from EOS-PM ($39 million) and EOSDIS ($8.4 million). Consistent with Congressional interest, $1 million is transferred from Launch Services for the Consortium (between JPL, University Nebraska and Johns Hopkins University) for the Application of Space Data to Education (CASDE). CASDE was created in response to a challenge to adapt NASA's data holdings and advanced information system technologies to improve education, to develop more science literacy, and to increase the awareness of space-based observation and research. Funding for the mission science teams is increased $1 1.5 million from EOS Special Spacecraft ($6 million) and EOSDIS ($5.5 niillion). Funding from EOS-PM for the airborne science and applications is increased $.6 million to cover unanticipated requirements for the aircraft transition from the Ames Research Center to the Dryden Flight Research Center. Funding for the commercial remote sensing program at the Stennis Space Center is increased by $5.5 million. This funding increase is offset by reductions to EOSDIS ($2.2 million) and Launch Services ($.3 million), as well as a reduction of ***$3*** million for the Uncrewed Aerial Vehicle (UAV) science program. The UAV science program is scaled back due to the slower than anticipated development of these types of aircraft. Total funding also reflects an increase of $13 million for consortia to develop regional applications using EOS data and an increase of $1 million for the United States/Mexico Foundation for Science as directed in House Report 105-297. These funding increases are offset by the reduction of $50 million for transfer to the Human Space Flight appropriation, as discussed above.

Funding for Mission Operations is increased $42.1 million. $3.4 million of this increase reflects reallocation of funding for the Alaska Synthetic Aperture Radar Facility (ASF), previously budgeted under EOSDIS, to consolidate management of ASF into one area. $4 million is reallocated from the mission science budget to separate the science in mission science teams from operational work in mission operations. $1.2 million of this increase reflects additional requirements for Upper Atmosphere Research Satellite (UARS), Ocean Topography Experiment (TOPEX/Poseidon), and the other operating Earth Science satellites. $3.5 million added to continue operations of the Satellite Laser Ranging (SLR) activities.

Funding for Launch Services is decreased $87.1 million, from $12 1.9 million to $34.8 million. $67.8 million of this reduction is primarily due to the transfers to the respective missions mentioned above. Funds remaining within Launch Services are for the EOS-AM and Landsat missions, which have launches in FY 1998. Funds from the Launch Services budget is realigned to the EOS-PM, new millennium, EOS Special Spacecraft, and Earth System Science Pathfinder budgets. The balance of $19.3 million has been applied to the “QuikScat” mission ($9.5 million), EOS Special Spacecraft ($2.5 million), EOS Technology Infusion ($4 million), Commercial Remote Sensing ($.3 million), CASDE ($1 million), consortia to develop regional applications using EOS data ($1 million) and United States/Mexico Foundation for Science ($1 million).

Earth Science funds are being used to procure required outfitting and equipment for special purpose areas in the Earth System Science Building (ESSB) at the Goddard Space Flight Center in FY 1998. The 1998 amount of $2.5 niillion, plus $1.2 million from the 1997 budget, is less than estimate with the original ESSB justification for outfitting.

	FY 1998			
	BUDGET ESTIMATE	APPROP TRANSFER	OTHER CHANGES	CURRENT ESTIMATE
Aeronautics and Space Transportation Technology	**1,469.5**	**-13.0**	**14.4**	**1470.9**
Aeronautics research and technology base	418.3		10.0	428.3
Aeronautics focused technology programs...........	501.8	-13.0	-10.0	478.8
High performance computing & communications ,	45.7			45.7
High-speed research..	245.0	-13.0		232.0
Advanced subsonic technology............................	211.1		-10.0	201.1
Advanced Space Transportation Technology	396.6		20.5	417.1
(Construction of Facilities)................................	[3.7]			13.71
Commercial Technology	152.8		-6.1	146.7

CHANGE FROM FY 1998 BUDGET ESTIMATE

Total funding for Aeronautics and Space Transportation Technology is increased a net of $1.4 million. This increase reflects an increase of $14.4 million as reflected in the FY 1998 Operating Plan, offset by a reduction of $13 million, as part of the transfer authority to be proposed by the Administration from the Science, Aeronautics and Technology appropriation to the Human Space Flight appropriation for the Space Station.

Funding for Aeronautical Research and Technology is $907.1 million, a reduction of $13 million from the FY 1998 budget request. Within Aeronautics Research and Technology Base, funding is increased $10 million as reflected in the FY 1998 Operating Plan, to support the Administration's Aviation Safety initiative. Funding for the Aeronautics Focused Technology Programs is reduced $23 million. Funding for the Advanced Subsonic Technology (AST) Program is reduced $10 million and reallocated to the R&T Base. This reduction is accommodated by reducing AST program reserves. Funding for High Performance Computing and Communications (HPCC) includes $10 million for NASA's FY 1998 contribution to the Government-wide Next Generation Internet initiative. This level of funding is consistent with Congressional direction. Funding for High Speed Research program is reduced $13 million, as part of the transfer authority to proposed by the Administration discussed above. This reduction will be accommodated by deferring some activities, with no impact to Level I milestones.

Funding for the Advanced Space Transportation Technology Program is increased $20.5 million to $4 17.1 niillion. Within this total, funding for the Bantam booster is increased by $20 million consistent with direction in House Report 105-297. Funding for this increase is made available as the result of a reallocation of $6.1 million from Commercial Programs, application of $4.4 niillion from the appropriations augmentation to the SAT account, and reallocation of $9.5 million within Advanced Space Transportation Technology. The $9.5 million is derived from $1.2 million from available uncosted balances and from $8.3 million in risk niitigation activities for the X-34 vehicle and propulsion systems. The reallocation of funds from Commercial Programs is made possible as a result of a recalculation of Small Business Innovative Research (SBIR) requirements. Consistent with direction in House Report 105-297, **NASA** is scheduled to hold a conference of interested parties on January 13-14, 1998, to address the optimal approach for post-cycle 1 efforts to achieve goals set out for the Bantam booster activity.

Within Advanced Space Transportation, an additional $10 million is included for studies in selected areas to support the National Space Transportalion Policy (NSTP). The NSTP calls for a decision by the end of the decade on whether to pursue development of a next-generation launch system. The NASA Space Transportation Council and external customers will review remaining open issues, including any additional funds required for the Liquid Flyback Booster (LFBB) activity. Additional candidate topics include technology studies in other innovative launch systems and components, including Phase III/IV Shuttle upgrades. This funding reflects application of the remaining $10 million added to the SAT appropriation by Congress in P.L. 105-65.

NASA has completed the preliminary phase of a review of the Agency's extramural research activities to assess required funding for the mandated SBIR and Small Business Technology Transfer (STTR) program. Based on those results, NASA has recalculated the funding necessary to meet SBIR/STTR requirements to be $101.5 million, a reduction of $23.5 million from last years planning assumption. Of this amount, $6.1 million is being reallocated to the Bantam booster effort, as noted above. The remaining $17.4 million is being reallocated within the Commercial Technology Program to offset additional requirements directed in House Report 105-297. We are continuing to refine our estimate and will continue Agencywide activity to ensure a high level of accuracy to the numbers.

Consistent with direction in House Report 105-297, funding for the following activities is included within Commercial Programs: $5.8 million for Commercial Technology; $1.9 million for the National Technology Transfer Center (NTTC) in Wheeling, West Virginia; $1.75 million for the Midwest Regional Technology Transfer Center; $1 million for eye tracking technology miniaturization; $1 million for a research and demonstration program to further accelerate the application of cool suit technology for multiple sclerosis patients; $1.5 million to restructure the Software Optimization and Reuse Technology effort, to be expended over 2 years; and $5 million for a NASA business incubator prograni designed to foster partnerships between educational institutions arid small, high-technology businesses. As stipulated in the House Report 105-297, NASA will compete this new technology incubator program nationwide, with a requirement that applicants demonstrate at least 50 percent of total funds can be derived from non-Federal sources. NASA expects to issue guidelines in January/February 1998, conduct the competition in March 1998, and select awardees during the suninier of 1998. Because it is critical that incubators be in close proximity to NASA Centers to leverage NASA technology, it is expected that NASA Centers will review proposals, make recommendations for selection, and manage selected incubators.

	FY 1998			
	BUDGET ESTIMATE	APPROP TRANSFER	OTHER CHANGES	CURRENT ESTIMATE
Mission Communication Services	**400.8**	**-5.0**		**395.8**
Ground Network..	224.7			224.7
Mission Control and Data Systems	145.0			145.0
Space Network Customer Services	31.1			31.1
Pending Reduction	0.0	-5.0		-5.0

CHANGE FROM FY 1998 BUDGET ESTIMATE

Funding for Mission Communications Services is reduced $5.0 million as part of the transfer authority to be proposed by the Administration from the Science, Aeronautics and Technology appropriation to the Human Space Flight appropriation. The source of funding for this reduction will be identified in a subsequent Operating plan, based on mid-year financial performance of program activities.

	FY 1998			
	BUDGET ESTIMATE	APPROP TRANSFER	OTHER CHANGES	CURRENT– ESTIMATE
Academic programs...	**96.4**	**-10.0**	**33.6**	**120.0**
Enterprise funding in support of Minority Programs	**[20.8]**			**120.81**

CHANGE FROM FY 1998 BUDGET ESTIMATE

Funding for Academic Programs totals $120.0 million, an increase of $23.6 million above the requested level, consistent with Congressional direction. This funding level represents a reduction of $10 million from the initial FY 1998 Operating Plan, reflecting the planned transfer authority to be proposed by the Administration for Space Station. Within this total, funding for Education Programs is increased $13.1 million and funding for Minority University Research Programs is increased $10.5 million. NASA is committed to meeting the Congressional direction included in House Report 105-297. NASA will fund these activities on an incremental basis as proposals are received, evaluated and implemented. Funding is included for the following items: Bishop Museum/National Prototype Space Education Curriculum ($1 million); Alaska Learning Center ($1.3M), Apple Valley, California Learning Center ($800 thousand); K-12 telecommunications ($2.0M); Louisiana Daily Living Center ($1.0M); Pennsylvania Education Telecommunications Center ($700 thousand); California Discovery Science Center ($500 thousand); Partnership Programs ($9.0 million); replication of the Science, Engineering, Mathematics and Aeronautics Academy (SEMAA) program ($1.5M).

MISSION SUPPORT

The funding level for the Mission Support appropriation of $2,388.2 million reflects a reduction of $125.0 million from the FY 1998 budget request. The distribution of this reduction, and other proposed funding reallocations, are included below.

	FY 1998			
	BUDGET ESTIMATE	APPROP TRANSFER	OTHER CHANGES	CURRENT ESTIMATE
Safety, Mission Assurance, Engineering, and Advanced Concepts..	**37.8**			**37.8**

CHANGE FROM FY 1998 BUDGET ESTIMATE

There is no change in total funding for activities managed by the Office of Safety, Mission Assurance, Engineering, and Advanced Concepts (SMAE&AC), the Office of the Chief Engineer, and the Office of the Chief Technologist.

	FY 1998			
	BUDGET ESTIMATE	APPROP TRANSFER	OTHER CHANGES	CURRENT ESTIMATE
Space Communication Services	**245.7**	**-15.0**	**-36.5**	**194.2**
Space network	161.2		-36.5	114.2
Telecommunications.,...	84.5			84.5
Pending Reduction		- 15.0		

CHANGE FROM FY 1998 BUDGET ESTIMATE

Funding for Space Comniunications Services is reduced $51.5 million from the FY 1998 budget request. Funding for Space Network is reduced $36.5 million, as reflected in the FY 1998 Operating Plan. This reduction reflects the reallocation of $25 million to the Human Space Flight appropriation by Congress and the reallocation of $1 1.5million to Research Operations support for additional implementation requirements for the agency-wide integrated Financial Management Program. An additional reduction of $1 5.0 million is included as part of the transfer authority to be proposed by the Administration for Space Station. The source of these funds will be included in a subsequent Operating Plan, based on mid-year financial performance of programs. The reinibursable budget authority which complements the NASA direct funding is $51.0 million.

	FY 1998			
	BUDGET ESTIMATE	APPROP TRANSFER	OTHER CHANGES	CURRENT ESTIMATE
Research and program management	**2,070.3**	**-18.0**	**-18.5**	**2,033.8**
Personnel and related cost	1,612.8	-15.0	-6.2	1,591.6
Travel	45.5	0.0	0.0	45.5
Research operations support	412.0	-3.0	-12.3	396.7

CHANGE FROM FY 1998 BUDGET ESTIMATE

Total funding for Research and Program Management is reduced $36.5 million. This reflects the net reduction of $18.5 million reflected in the FY 1998 Operating Plan, and an additional reduction of $18.0 niillion as part of the planned transfer authority to be proposed by the Administration for Space Station. This additional reduction is accommodated based on savings available from the most recent buyout and a reduction of $3 million in Research Operations Support funding.

The reduction of $18.5 million included in the FY 1998 Operating Plan reflects a reduction to Personnel and Related Cost of $6.2 million and a reduction to funding for Research Operations Support of $12.3 million. Funding for Personnel and Related costs is reduced $6.2 million, which is reallocated to Research Operations Support for additional support to the Integrated Financial Management Program at NASA Headquarters. Funding for Research Operations Support reflects a net reduction of $12.3 million. This reduction is derived from a reallocation of $30.0 million to Human Space Flight for the ISS program as part of the $80.0 reallocation included in P.L. 105-65, offset by reallocation of the $1 1.5million from Space Communications to support the FY 1998 implementation activities associated with the lntegrated Financial Management Program at the Hunian Space Flight Centers, and the reallocation of $6.2 million from Salaries and Expenses addressed above.

	FY 1998 BUDGET ESTIMATE	AF'PROP TRANSFER	OTHER CHANGES	CURRENT ESTIMATE
Construction of Facilities..................................	**159.4**	**-12.0**	**-25.0**	**122.4**

CHANGE FROM FY 1998 BUDGET ESTIMATE

Funding for CoF totals $122.4 million, a reduction of **$37** million from the FY 1998 request. This reflects the reduction of $25 million included in the FY 1998 Operating Plan and an additional reduction of $12 million as part of the transfer authority to be proposed by the Administration for Space Station. The reduction of $25 million included in the Operating Plan reflects reallocation of $20 million from the Environmental Compliance and Restoration Program and reallocation of $5 million from other CoF activities to the Human Space Flight appropriation, as included in P.L. 105-65. The additional $12 million reduction is part of the transfer authority to be proposed by the Administration for Space Station. This reduction **will** be accommodated by deferring planned activities and by using available uncosted funds to accomplish the FY 1998 program. The CoF funding includes $5 million for facilities enhancements at the Stennis Space Center, as directed in the Conference Report.

	FY 1998 BUDGET ESTIMATE	AF'PROP TRANSFER	OTHER CHANGES	CURRENT ESTIMATE
INSPECTOR GENERAL	**18.3**	**0.0**	**0.0**	**18.3**

CHANGE FROM FY 1998 BUDGET ESTIMATE

There is no change in funding for Inspector General activities.

Special Issues

NATIONAL AERONAUTICS **AND** SPACE ADMINISTRATION
FISCAL ***YEAR*** 1999 BUDGET ESTIMATES
FULL-COST MANAGEMENT

During 1995, the National Aeronautics and Space Administration (NASA)began a multi-year initiative to introduce full-cost practices into NASA. Full-cost practices involve new management, budgeting, and accounting changes. The changes are designed to support improved (more cost effective) mission performance and related administrative improvements. Full-cost practices (also for brevity collectively referred to as full-cost management) integrate new cost accounting infomiation on all aspects of NASA's activities. This information will be used by managers to ensure that all activities cost effectively support NASA missions. Full-cost budget inforniation will highlight the full cost (including support costs) of each NASA project and thereby support more complete, "full" disclosure of NASA's activities, clearer linkage between resource inputs and outputs/outcomes, and greater accountability regarding NASA's use of taxpayer resources. NASA will more efficiently, effectively, and economically control and manage all Agency resources/costs, thereby enhancing related mission and administrative efficiencies.

NASA plans to fully implement all full cost practices in Fiscal Year (FY) 2000. This implementation is contingent upon certain related activities, such as, (1) agreements between NASA, the Administration and the Congress regarding a new appropriation/budget structure and related authorities for efficient implementation and (2) the timely iniplementation of an ongoing, related NASA initiative to implement a standard, integrated financial management system by FY 2000. NASA's system initiative is underway. NASA also has been working with the Office of Management and Budget regarding a new appropriation/budget structure and plans to initiate related discussions with key Congressional committees during the coming months in conjunction with the FY 1999 budget review process.

NASA's full cost practices are designed to provide useful, detailed cost infomiation for internal management and appropriate cost inforniation for external oversight. Such inforniation is expected to result in improved decisions and more cost effective mission performance. NASA's practices also comply with related Federal legislation, such as the 1990 Chief Financial Officers (CFO) Act, the 1993 Government Performance and Results Act (Results Act) and the 1996 Federal Financial Management Improvement Act.

NASA has tested full-cost concepts across the agency and determined the feasibility of iniplenientation and anticipated benefits. NASA stands ready to implement full-cost practices beginning with the FY 2000 budget request. This document summarizes the status, purpose and background of NASA's full-cost initiative. It also highlights key legislative authorities that will support the timely, effective implementation of full cost practices in NASA. Supplemental information is available through the NASA CFO internet site at **http://booster.nasa.gov:443/codeb/fcdocs.htm.**

Status

During 1997, NASA completed a comprehensive test of full-cost concepts at all Centers and at Headquarters. The test focused on (1) testing full-cost budgeting by recasting the FY 1999 budget into a full-cost format; (2) testing full-cost accounting by applying cost finding techniques to six months of FY 1997 accounting data to determine program/project costs; and (3) identifying issues which needed to be resolved before full-cost implementation.

The 1997 agency-wide test indicated that NASA could benefit significantly from the introduction of full-cost practices throughout the agency. The 1997 test also confirmed that NASA needed a new integrated financial system to cost effectively and efficiently support full cost budgeting and accounting. Cost finding techniques proved to be extremely resource-intensive and could not produce needed data in a timely fashion. Furthermore, the timely, efficient formulation of the budget in a full cost format also proved to be extremely resource-intensive and basically unworkable as an ongoing approach.

During 1998, NASA plans to continue testing and refining full-cost practices. Additional development work will be conducted regarding service pools and General and Administrative (G&A) cost pools. Such pools represent accounts that collect and subsequently distribute agency costs for related activities. In the case of service pools, mechanisms are needed to capture consumption data and to link cost and consumption data in order to develop cost per unit of service consumed. With regard to G&A pools, there is a need to develop approaches for obtaining Full-Time Equivalent data for on-site direct civil service and contractor personnel to serve as the basis for G&A distribution.

During 1999, NASA plans to implement the Integrated Financial Management system that will support efficient operation of NASA in a full-cost environment. Testing will focus primarily on implementation of full cost accounting and budgeting as an integral part of the Integrated Financial Management system implementation effort. In 2000, NASA plans to be fully operational in terms of management, budgeting, and accounting on a full-cost basis.

Purpose

The purpose of the full-cost initiative is to develop and implement full-cost accounting, budgeting, and management practices in NASA. The purpose of implementing such full-cost management is to support cost-effective mission performance through timely, reliable financial information and practices.

Simply stated, full-cost management can be expected to help to ensure optimum mission performance with the minimum essential resources. In that regard, full-cost practices are expected to:

- support more cost effective mission performance
- motivate managers to operate efficiently
- support economic decisions for appropriate resource allocations
- help justify NASA's budget on a program/project basis
- support analysis and decision-making regarding full project cost
- support analysis and decision-making regarding NASA services provided to others (reimbursable activities)
- support bench-marking of NASA service activities with other similar services, and
- support strengthened accountability regarding NASA's effective and efficient use of tax dollars to achieve NASA missions.

NASA is pursuing full-cost management at this time because NASA requires related cost information to more effectively manage within the current and anticipated future environment. This environment includes constrained budgets and increased expectations regarding oversight and accountability.

Background

NASA's full-cost management initiative began in 1995 in response to guidance from several NASA and Federal authorities. While the initiative was undertaken in direct response to a specific management initiative of the NASA Administrator, the initiative also responded to guidance indicated in NASA's 1995 Zero Base Review and mandates in several key Federal financial and performance laws and related standards.

In early 1995, the NASA Administrator requested information regarding overhead costs in NASA arid at each NASA Center. In pursuing the Administrator's request, the NASA CFO confirmed that NASA's nonstandard, decentralized accounting systems did not regularly capture certain cost information. Shortly thereafter, in April 1995, NASA initiated its full-cost effort.

During 1995, NASA also completed a Zero Base Review that involved a comprehensive analysis related to streamlining NASA activities. This review also highlighted several weaknesses involving the inconsistent recognition of the total costs of certain NASA activities and the related analytical complications of inconsistent cost information. The Zero Base Review team indicated that NASA should improve cost information and pursue full-cost management.

During 1995, Federal accounting standards-selling Organizations also completed key initiatives related to cost accounting. These organizations approved a new managerial cost accounting standard, including a specific standard on full-cost accounting. This standard (and other Federal accounting standards) evolved from recent Federal financial and performance legislation.

During the past few years, financial and perforniance legislation highlighted key Federal cost accounting and reporting requirenients. This legislation included the CFO Act of 1990 and the Government Performance and Results Act of 1993. In addition, more recently the Federal Financial Management Improvement Act of 1996 highlighted and specified other key full-cost accounting requirements. The 1996 Act stated the following.

> "The purposes of this Act are to...require Federal financial systems to support full disclosure of Federal financial data, including the full costs of Federal programs and activities, to the citizens, the Congress, and President, and agency management, so that programs and activities can be considered based on their full costs and merits..."
>
> "Each agency shall implement and maintain management systems that comply substantially with Federal financial management systems requirements, applicable Federal accounting standards, and the United States Government's Standard General Ledger at the transaction level."

NASA's full-cost initiative evolved from these internal NASA initiatives, as well as, several related Governmentwide initiatives.

During 1995, NASA developed key full-cost concepts and specified related cost information requirements as part of an ongoing Integrated Financial Management system initiative. NASA's full-cost concepts were approved by NASA management in early 1996.

NASA's full-cost concept integrates several fundamental improvements. The planned improvements include accounting for all NASA costs as direct costs, service costs, or general and administrative (G&A) costs, budgeting for all appropriate program/project/initiative ("project") costs, and managing such "projects" from a full-cost perspective. Direct costs are costs that can be obviously and/or physically linked to a particular project. Service costs are costs that cannot be initially, readily and/or immediately linked to a project, but subsequently can be traced to a project (optimally based on service consumption). G&A costs are support costs that cannot be linked to a specific project in an economical manner. Such costs are typically allocated to cost objects (or projects) on a reasonable, consistent basis.

During 1996, NASA tested full-cost concepts at four NASA prototype test locations (three Centers and Headquarters). The prototype test indicated that NASA could benefit significantly from the introduction of full-cost practices throughout the agency. During 1997, NASA completed ***an*** agency-wide test of full-cost practices that confirmed its earlier observations that NASA could benefit significantly from the implenientation on full-cost practices.

Legislative Proposals for Optimum Full-Cost Management

The strength and benefits of NASA's full cost practices are optimized by the integration and synergy of changes in each area (management, budgeting, and accounting). Full-cost accounting by itself, over time, would likely lead to gradual budget and management improvements. However, concurrent changes to full cost practices in the accounting, budgeting, and management areas can be expected to ensure that NASA optimizes improvements in each area, as soon as possible. To this end, NASA has decided to pursue key appropriation/budget structure changes as part of the full cost initiative. Furthermore, certain legislative provisions are being pursued to ensure that NASA achieves all of the key benefits of its full-cost practices, while NASA retains its long-standing ability to appropriately and efficiently assign/reassign its staff to achieve mission requirements.

NASA plans to work with OMB and Congress during 1998 to determine the specific appropriation/budget structure and related authorities that are appropriate to support the planned FY 2000 implenientation of full cost practices in NASA. In that regard, NASA has highlighted key legislative language that will support the planned 1998 internal NASA budget forniulation activities of the planned FY 2000 budget request. NASA is requesting that this language be included in the FY 1999 Appropriation/Authorization laws. The proposed language follows.

"NASA should develop a revised appropriation structure for submission in the Fiscal Year 2000 budget request consisting of two basic appropriations (the Human Space Flight Appropriation and the Science, Aeronautics and Technology Appropriation) with a separate (third) appropriation for the Office of the Inspector General. The basic appropriations should each include the planned full cost (direct and indirect costs) of NASA's related activities and should each include authorities for NASA to shift civil service salaries, benefits arid support between and/or among appropriations or accounts, as required, for the safe, timely, and successful accomplishment of NASA missions."

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1999 BUDGET ESTIMATES

MULTI-YEAR APPROPRIATIONS
(IN MILLIONS OF REAL YEAR DOLLARS)

NASA is seeking multi-year appropriations for the following selected projects:

	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
INTERNATIONAL SPACE STATION	2,270.0	2,134.0	1,933.0	1,766.0	1,546.0	350.0

National Aeronautics and Space Administration

Major NASA Development Programs
Program Cost Estimates

This special section of the FY 1999 budget Justifications provides information about major NASA programs that are either in the design and development phase or have not completed their initial operational phase. In several instances, informatton about programs which are not "major" but are of special interest has been included. The budgetary estimates are expressed in millions of dollars of budget authority. * Estimates of the FY 1997 and prior fiscal year budget authority are the "actual" amounts. The FY 1998 amounts are consistent with the FY 1999 budget request. The amounts for FY 1999 and future fiscal years are expressed in "real year" economics, that is, they include an adjusting factor for the future inflation expected to be experienced. If the term "constant dollars" is used in the budget justifications, that phraseology indicates that the numbers do not include inflationary adjustments beyond the fiscal year referenced (e.g., "constant FY 1994 dollars").

The estimates provided below are intended to be comprehensive, Including all related mission-unique costs, but there are limitations. The direct and indirect costs Incurred by foreign governments or other federal agencies in support of these rnlssions have not been included. (The reader is referred to the NASA Program Status Reports, a biannual document published by NASA, for the most accurate information available to NASA on the amounts Incurred or to be incurred.) The estimates of civil service costs have been included, but these estimates should be considered preliminary, and they will continue to be refined as the agency moves toward full cost accounting over the next two years.

* Budget authority is a term used to represent the amounts appropriated by the Congress in a glven fiscal year: budget authority provides government agencies with the authority to obligate funds. The ensuing obligations, cost incurrence, and expenditures (outlays) can differ in timing from the fiscal year in which Congress provides the budget authority in an appropriations act.

High Sueed Research Program

The High Speed Research Program is a cooperative government-industry program to develop the technologies required by U.S. firms to design and build an environmentally compatible and economically competitive high-speed civil transport aircraft for the 21st century. The High-speed Research (HSR) program goal Is to develop enabling technologies and reduce the technology risk by an order of magnitude so that the U.S. Industry can embark upon a decision to produce HSCT aircraft. NASA is concentrating its investments In the early, high-risk stages of development and the aircraft manufacturing industry has indicated that it Is willing to make a substantial investment in this program as the technological risk decreases.

The program consists of two phases. Phase I, initiated in FY 1990 and completed in FY 1995, defined High Speed Civil Transport (HSCT) environmental compatibility requirements in the critical areas of atmospheric effects, community noise and sonic boom and established a technology foundation to meet these requirements. Initiated In FY 1994, Phase II is a cooperative program with U.S. industry and is directed at developing and validating designs, design methodologies and manufacturing process technology for subsequent application by industry in future HSCT aircraft programs to ensure environmental compatibility and economic viability. This phase will conclude in 2002. In FY 1999, NASA has proposed an extension to the program, HSR Phase IIA, which will mitigate risk in two critical areas — propulsion and airframe materials and structures. HSR Phase IIA will enable American taxpayers to continue to receive a return on their investment in high-speed research and will be essential to enabling U.S. industry to make Its decisions on whether the 21st Century commercial aircraft market will call for an HSCT. It should be noted that the government funding does not provide for the development of a prototype aircraft.

The budgetary estimates provided below are the amounts included in the specific budget justification within the Aeronautics section in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts being contributed by industry, or for the use of government facilities and general support used to carry out the research. A more detailed exposition of the program goals, objectives and activities Is provided in the specific budget justification narrative.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
TOTAL EXCLUDJNG CIVIL SERVICE COSTS ($M)	891.4	243.1	232.0	190.0	172.8	152.8	172.6	156.8	374.8	2586.2
(ESTIMATED CIVIL SERVICE FTEs)	(2,434)	(589)	(588)	(532)	(463)	(307)	(268)	(268)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	154.7	45.8	47.1	44.1	39.8	27.2	24.9	26.1		

Advanced Subsonic Technology

The Advanced Subsonic Technology (AST) program is a cooperative government-industry program to develop technologies in areas where such developments will facilitate the economic and technological competitiveness of U.S. subsonic aircraft producers. These developments include not only airframe, engine, and avionics technology improvements, but also short-haul aircraft, environmental studies, efficiency and safety improvements, advanced air traffic technology, and aircraft design and manufacturing tools. This systems technology focused program was preceded by activities funded within the research **arid** technology base for many years. The specific objectives set forth for this program are intended to be completed by FY 2004. In FY 1997, the eight program elements of the AST program were realigned within the following four major elements: (1) Safety, which includes the Aging Aircraft element and the ice protection and human interface with flat panel displays portions of General Aviation; (2) Environment, including the Noise Reduction and Environmental Assessment elements and the emissions portion of the Propulsion element; (3) Capacity. including the TAP, Advanced Air Transportation Technology and Civil Tiltrotor elements; and (4) Reduced Seat Cost, including the Integrated Wing Design, Technology Integration and Composites elements, the turbine and compressor portions of the Propulsion element and the remaining efforts in General Aviation.

The budgetary estimates provided below are the amounts included in the specific budget justification within the Aeronautics section in the Science, Aeronautics and Technology appropriation for this program. As such, they do not include the amounts being contributed by industry, or for the use of government facilities and general and administrative support used to carry out the research. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	402.3	173.6	201.1	157.4	103.5	135.8	116.8	127.8	493.3	1911.6
(ESTIMATED CIVIL SERVICE FTEs)	(1,309)	(568)	(545)	(535)	(535)	(549)	(521)	(521)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	88.4	44.2	43.6	44.4	46.0	48.6	48.3	50.8		

X-33 Advanced Technology Demonstrator

The X-33 program will demonstrate, on the ground and on a flight demonstration vehicle, technologies and operations concepts that could reduce space transportation costs to one-tenth of their current level. The National Space Transportation Policy directed the X-33 program to include two major decision points. The first decision, whether to proceed with the demonstration phase (Phase II), was made in July 1996 based on specific programmatic, business planning and technical criteria which had previously been agreed upon by NASA, the Office of Management and Budget and the Office of Science and Technology Policy. With Administration approval, Lockheed Martin Skunkworks, Palmdale, CA was chosen as the X-33 industry partner. X-33 flight tests are expected to begin in July, 1999. The second decision will be made at the end of the decade, after X-33 ground and flight tests, when Government and industry will consider whether private financing of the full-scale development of an operational RLV (Phase III) should be pursued.

NASA is utilizing an innovative management strategy for the X-33 program, based on industry-led cooperative agreements. As a result of industry's leadership of the program, Government participants are acting as partners and subcontractors, performing only those tasks which offer the most effective means to accomplish the program's goals. The Government participants report costs and manpower to the industry team leader as would any other subcontractor. Every NASA center except the Goddard Space Flight Center has a negotiated role on the X-33 program. The Industry-led cooperative arrangement allows a much leaner management structure, lower prograni overhead costs and increased management efficiency

The X-33 program also funds refurbishment of rocket engine test stands at Stennis in FY 1997 ($2.3 million) and FY 1998 ($3.7 million) to enable testing of X-33 development and flight engines, as well as other future advanced space transportation engines. Civil Service estimates below are for the X-33 cooperative agreement only, and represent data available as of January 13, 1998.

A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
COOPERATIVE AND TASK AGREEMENTS	39.0	223.1	298.6	244.6	106.1					911.4
OTHER X-33 ACTIVITIES	210.7	38.9	19.7	38.2						307.5
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)*	249.7	262.0	318.3	282.8	106.1					1218.9
(ESTIMATED CIVIL SERVICE FTEs)	(59)	(276)	(311)	(289)						
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	5.1	21.5	24.9	23.9						

* Note: Total X-33 cost has increased compared to the FY 98 Budget estimate only because FY 1994-1995 costs have been added for completeness. FY 1996-2000 estimates have been rephased to reflect BA requirements, but total costs have not changed.

Alternate Turbopump Development

Funding to begin development of an alternate design for the two turbopumps driving the Space Shuttle's Main Engine was initiated in FY 1987. The development of a new high-pressure oxygen turbopump and hydrogen fuel turbopump was undertaken to improve the safety, reliability, producibility, and maintainability of the current turbopumps. After an initial period of design and development, problems experienced in early development testing and accompanying increased costs resulted in suspension of the fuel turbopump's development, while development activities concentrated on the oxygen turbopump. Although further development problems were encountered with the oxygen turbopump, their successful resolution led to Congress agreeing in Spring 1994 to resumption of the fuel turbopump's development. The first flight of the oxygen turbopump occurred in 1995, and the initial flight of the fuel pump is currently planned for late 1998, rescheduled from late 1997 due to development problems. The budgetary estimate of $979.2 million includes not only the funding required for the design, development, and extensive testing of these two types of turbopumps, but also the funding needed to produce the flight turbopumps for installation into the main engines for the four-orbiter fleet.

The budgetary estimates provided below are the amounts included in the Human Space Flight appropriation for this program. They do not include the amounts for the use of government facilities and general and administrative support used to carry out the development. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Shuttle program.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	623.5	49.6	32.1	21.8	11.1				32.6	770.7
IMPLEMENTATION	86.7	30	40	41.9	9.9					208.5
TOTAL EXCLUDING CML SERVICE COSTS ($M)	710.2	79.6	72.1	63.7	21.0				32.6	979.2
(ESTIMATED CML SERVICE FTEs)	(465)	(84)	(68)	(51)						
CML SERVICE COMPENSATION ESTIMATE ($M)	26.5	6.5	5.4	4.2						

Super Lightweight Tank

The design and development of a lighter external tank for the Space Shuttle was undertaken in 1993 after tests of new aluminum-lithium materials indicated that a significantly lighter external tank could be produced. The anticipated weight savings of approximately 7500 pounds would recover some of the ascent performance losses resulting from safety and reliability improvements instituted after the Challenger disaster. Coupled with other performance gains, the super lightweight tank will facilitate the Space Shuttle's operations at new higher inclination orbit established in 1993 for the international Space Station. The first launch of a Space Shuttle with the new tank is planned for May 1998. In addition to the design and development costs, the figures shown below as "recurring cost" provide the estimate of the funding required for the external tank program's production of the new tanks. The estimates include the additional material cost which will be incurred in the production of subsequent tanks. The aluminum-lithium material is a specialty metal produced to rigorous specifications and accordingly costs more than the aluminum used at present. The development cost estimate is significantly reduced from the **FY** 1998 estimate, as contract performance exceeded expectations and project reserves were not required.

The budgetary estimates provided below are the amounts included in the Human Space Flight appropriation for this program. They do not include the amounts for the use of government facilities and general and administrative support used to carry out the development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Shuttle program.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT COST	122.7	6.0	1.8							130.5
RECURRING COST	56.0	35.0	33.1	33.1	8.5				Continues	
TOTAL EXCLUDING CML SERVICE COSTS ($M)	178.7	41.0	34.9	33.1	8.5					
(ESTIMATED CML SERVICE FTEs)	(151)	(51)	(29)	(21)	(17)					
CML SERVICE COMPENSATION ESTIMATE ($M)	10.8	4.0	2.3	1.7	1.5					

TDRS Replenishment Spacecraft Program

The Tracking and Data Relay Satellite (TDRS) Replenishment Spacecraft program ensures sufficient spacecraft will be available to continue Space Network operations into the next century. The program provides three additional TDRS satellites and ground terminal modifications through a fixed price, commercial practices contract with Hughes Space and Communications Company. This innovative approach has deleted or greatly reduced Government specifications and documentation requirements, allowing the contractor to substitute commercial practices; this has resulted in efficiencies in both cost and development lead time.

These satellites will incorporate Ka-band frequencies, where space research has a primary allocation, into the high data rate services provided via the high gain, single access antennas. The single access services at S-band and Ku-band will be retained, remaining backward compatible with the existing, first generation TDRS satellites. These satellites will also provide an enhanced multiple access service with data rates up to three megabits per second. The first spacecraft remains on schedule for launch in the third quarter of 1999.

The estimates do not include costs for use of government facilities and general and administrative support used to carry out the program. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification for the program within the Space Communications section.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
SPACECRAFT DEVELOPMENT AND GROUND TERMINAL MODIFICATIONS	194.8	162.1	56.0	73.3	10.6	17.8	51.1	52.6		618.3
LAUNCH SERVICES	6.8	17.9	54.5	47.1	47.4	52.2	47.1			273.0
TOTAL EXCLUDING CML SERVICE COSTS ($M)	201.6	180.0	110.5	120.4	58.0	70.0	98.2	52.6		891.3
(ESTIMATED CML SERVICE FTEs)	(65)	(54)	(59)	(59)	(41)	(45)	(51)	(49)		
CML SERVICE COMPENSATION ESTIMATE ($M)	4.4	4.2	4.7	4.9	3.5	4.0	4.7	4.8		

Advanced X-Ray Astrovhvsics Facility

The design and development of the Advanced X-Ray Astrophysics Facility (AXAF)was approved by Congress in the FY 1989 budget. The AXAF is the third of the four "Great Observatories" intended to observe the universe in four electromagnetic spectrum regions: visible, infrared, gamma ray, and x-ray. The initial phase of the AXAF's development was limited to a feasibility demonstration of the new mirror technology required to achieve the AXAF's objectives. A specially designed x-ray calibration facility was constructed to assure the mirrors meet their design specifications. The second phase was approved by Congress after the demonstration mirrors were successfully tested. In 1992, NASA management directed the restructuring of the AXAF program to reduce projected future funding requirements. A two-spacecraft approach was selected, a large imaging spacecraft (AXAF-Imaging) and a smaller spectroscopy spacecraft (AXAF-Spectroscopy). In 1993, Congress directed the elimination of the AXAF-S. The launch of the AXAF-I spacecraft is scheduled for no later than January 1999 aboard the Space Shuttle, with an Inertial Upper Stage (IUS) providing delivery into a highly elliptical orbit around the Earth. The budgetary estimates provided below encompass: the early development of the mirror technology; the design and development phase; establishment of a mission-unique science center and preflight ground system development, followed by a five-year period (1999-2003) of mission operations and science data analysis; the purchase of the IUS and integration activities; the average cost (including recurring costs for improvements and upgrades) of an FY 1998 Space Shuttle flight; mission-unique tracking and data support costs; and, the construction of the X-Ray Calibration Facility.

The estimates provided below include a pro forma distribution of the average costs of a Space Shuttle. They do not include the amounts being contributed by international participants, or for the use of non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
ADVANCED TECH DEVELOPMENT	54.2									54.2
DEVELOPMENT	1181.4	184.4	95.8							1461.6
MISSION OPS & DATA ANALYSIS	92.9	35.5	41.5	63.3	63.0	67.0	60.9	63.0	25.6	512.7
UPPER STAGE	47.9	17.7	5.3							70.9
STS LAUNCH SUPPORT		191.5	76.5	114.9						382.9
TRACKING & DATA SUPPORT	0.8	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.3	2.8
CONSTRUCTION OF FACILITIES	17.7									17.7
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	1394.9	429.5	219.4	178.4	63.2	67.2	61.1	63.2	25.9	2502.8
(ESTIMATED C M L SERVICE FTEs)	(1321)	(207)	(147)	(50)	(33)	(33)	(33)	(33)		
C M L SERVICE COMPENSATION ESTIMATE ($M)	80.9	16.1	11.8	4.1	2.8	2.9	3.1	3.2		

Space Infrared Telescope Facility (SIRTF)

The purpose of the Space Infrared Telescope Facility (SIRTF) mission is to explore the nature of the cosmos through the unique windows available in the infrared portion of the electromagnetic spectrum. SIRTF is the fourth of NASA's Great Observatories, which include the Hubble Space Telescope, the Compton Gamma Ray Observatory, and the Advanced X-Ray Astrophysics Facility. The funding plan provided below reflects a dramatic restructuring of the SIRTF design concept carried for many years. Rather than simply "descoping" the "Great Observatory" concept to fit within a $400 million (FY94 $) cost ceiling imposed by NASA, scientists and engineers have instead redesigned SIRTF from the bottom-up. The goal was to substantially reduce costs associated with every element of SIRTF -- the telescope, instruments, spacecraft, ground system, mission operations, and project management. The Jet Propulsion Laboratory (JPL) was assigned responsibility for managing the SIRTF project. SIRTF is planned for launch on a Delta launch vehicle during FY 2002.

The budgetary estimates below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts for the definition phase studies carried out prior to FY 96. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
ATD	15.0	24.9	40.0							79.9
DEVELOPMENT			55.4	111.7	101.1	90.6	19.2			378.0
MISSION OPS & DATA ANALYSIS							20.0	79.0	240.0	339.0
LAUNCH SUPPORT				8.0	18.4	28.4	11.0			65.8
TRACKING & DATA SUPPORT				tbd	tbd	tbd	tbd	tbd	tbd	tbd
TOTAL EXCLUDING C M L SERVICE COSTS ($M)		24.9	95.4	119.7	119.5	119.0	50.2	79.0	240.0	862.7
(ESTIMATED C M L SERVICE FTEs)	(3)	(26)	(33)	(37)	(33)	(25)	(34)	(34)		
C M L SERVICE COMPENSATION ESTIMATE ($M)	0.2	2.0	2.6	3.1	2.8	2.2	3.2	3.3		

Relativity Mission/Gravity Probe-B

The development of the Relativity mission began in 1993. after many years of studying mission design alternatives and developing the advanced technologies required for this mission to verify Einstein's theory of general relativity. The award of the spacecraft development contract was made in 1994. The scheduled launch date is March 2000, using a Delta II launch vehicle. The estimates provided below include funding for the experiment development activities, a minimum of 16 months of mission operations, and the launch services.

The budgetary estimates below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts for the definition phase studies carried out from FY 1985-87, but they do provide the amounts for the Shuttle Test of Relativity Experiment program initiated in FY 1988 and subsequently restructured into a ground test program only. The estimates also exclude the non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	271.3	59.6	57.3	37.6	30.1	3.9				459.8
MISSION OPS & DATA ANALYSIS					9.1	9.6	2.3			21.0
LAUNCH SUPPORT		6.8	9.2	19.9	16.7	0.2				52.8
TRACKING & DATA SUPPORT							TBD			TBD
TOTAL EXCLUDING C M L SERVICE COSTS ($M)	271.3	66.4	66.5	57.5	55.9	13.7	2.3			533.6
(ESTIMATED CIVIL SERVICE FTEs)	(77)	(13)	(13)	(10)	(10)	(10)	(10)	(10)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	4.6	1.0	1.0	0.8	0.9	0.9	0.9	1.0		

Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED]

The TIMED mission is the first science mission in the Solar Terrestrial Probes (STP) Program, and is part of NASA's initiative aimed at providing cost-efficient scientific investigation and more frequent access to space. TIMED will be developed for NASA by the Johns Hopkins University Applied Physics Laboratory (APL). The Aerospace Corporation, the University of Michigan, NASA's Langley Research Center with the Utah State University's Space Dynamics Laboratory, and the National Center for Atmospheric Research will provide instruments for the TIMED mission.

TIMED is scheduled for launch in May 2000 aboard a Med-Lite Class launch vehicle. TIMED began its 36-month C/D development period in April 1997. The budgetary estimates below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts for the definition phase studies carried out from April 1996 to April 1997.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT		25.9	52.7	40.8	9.9					129.3
MISSION OPS & DATA ANALYSIS					9.2	12.8	9.0	7.2		38.2
LAUNCH SUPPORT			13.0	11.5	6.1					30.6
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)		25.9	65.7	52.3	25.2	12.8	9.0	7.2		198.1
(ESTIMATED CIVIL SERVICE FTEs)		(21)	(14)	(14)	(15)	(10)	(11)	(11)		
C M L SERVICE COMPENSATION ESTIMATE ($M)		1.6	1.1	1.2	1.3	0.9	1.0	1.1		

The Explorer Program

The Explorer program consists of small to mid-sized spacecraft conducting investigations in all space physics and astrophysics disciplines. The program provides for frequent, relatively low-cost missions to be undertaken as funding availability permits within an essentially level overall funding profile for the program. The funding profile provided below covers the design and development phase, launch services, mission-unique tracking and data acquisition support, mission operations and data analysis. It does not include costs for the use of government facilities and general and administrative support required to implement the program. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
Advanced Composition Explorer	139.3	31.4	7.4	7.0	7.0	4.0	3.9			200.0
Far Ultraviolet Spectroscopy Explorer	74.8	26.6	38.4	13.2	13.4	14.4	7.0			187.8
Imager for Magnetospause-to-Aurora Global Explora	12.3	27.3	39.2	46.3	9.8	7.1	11.4	2.1		155.5
Microwave Anisotropy Probe	5.4	17.1	26.0	43.4	30.8	18.6	6.6	6.6		154.5
*SWAS, TRACE, WIRE	150.3	24.7	32.8	12.7	7.3	4.8	0.6	0.4		233.6
*STEDI (SNOE, TERRIERS, CATSAT)	27.7	5.3	7.0	0.4						40.4
*HETE-II		1.4	8.7	6.4	1.5	1.5				19.5
*Planning & Future Developments		17.9	24.8	92.1	121.6	162.8	221.5	265.2	CONT	
TOTAL EXCLUDING CML SERVICE COSTS ($M)		151.7	184.3	221.5	191.4	213.2	251.0	274.3	CONT	
(ESTIMATED CML SERVICE FTEs)	(100)	(263)	(264)	(268)	(230)	(217)	(188)	(188)	(Cont.)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	7.2	20.5	21.1	22.2	19.8	19.2	17.4	18.3	Cont.	

*Tracking estimate is not included

Advanced Composition Explorer

Development on the Advanced Composition Explorer (ACE) began in FY 1994. The spacecraft is being built by the Johns Hopkins Applied Physics Lab; instruments are being managed by the California Institute of Technology. ACE launched in August 1997 on a Delta II launch vehicle.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	95.8	12.7								108.5
MISSION OPS & DATA ANALYSIS			6.6	6.7	6.7	3.9	3.8			27.7
LAUNCH SUPPORT	34.9	15.1								50.0
TRACKING & DATA SUPPORT	8.6	3.6	0.8	0.3	0.3	0.1	0.1			13.8
TOTAL	139.3	31.4	7.4	7.0	7.0	4.0	3.9			200.0

Far Ultraviolet Spectroscopic Explorer

Development on the Far Ultraviolet Spectroscopy Explorer (FUSE) began in FY 1996. The FUSE mission has been restructured from a Delta-class explorer in order to reduce costs and accelerate the launch date from CY 2000 to November 1998. FUSE is being managed by Johns Hopkins University, with contributions from the University of Colorado, the University of California-Berkeley, Orbital Sciences Corp., Canada and France.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	56.6	26.0	22.8	2.6						108.0
MISSION OPS & DATA ANALYSIS			0.3	10.6	13.4	14.4	7.0			45.7
LAUNCH SUPPORT	18.2	0.6	15.3							34.1
TOTAL	74.8	26.6	38.4	13.2	13.4	14.4	7.0			187.8

Imager for Magnetopause-to-Aurora Global Exploration

Development on the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE)began in FY 1997. The IMAGE mission will use three-dimensional imaging techniques to study the global response of the Earth's magnetosphere to variations in the solar wind, the stream of electrified particles flowing out from the Sun. The magnetosphere is the region surrounding the Earth controlled by its magnetic field and containing the Van Allen radiation belts and other energetic charged particles. Southwest Research Institute has been selected to develop the IMAGE mission. IMAGE is scheduled for launch in January 2000 aboard a Delta-7326 (Med-Lite Class ELV).

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	8.3	24.0	26.4	19.7	5.2					83.6
MISSION OPS & DATA ANALYSIS					4.6	7.1	11.4	2.1		25.2
LAUNCH SUPPORT	4.0	3.3	12.8	26.6						46.7
TOTAL	12.3	27.3	39.2	46.3	9.8	7.1	11.4	2.1		155.5

Microwave Anisotropy Probe

Development on the Microwave Anisotropy Probe (MAP)began in FY 1997. The MAP mission will undertake a detailed investigation of the cosmic microwave background to help understand the large-scale structure of the universe, in which galaxies and clusters of galaxies create enormous walls and voids in the cosmos. GSFC is developing the MAP instruments in cooperation with Princeton University. MAP will launch in November 2000 aboard a Delta-7326 (Med-Lite Class ELV).

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	5.4	15.7	19.8	25.0	16.1	6.3				88.3
MISSION OPS & DATA ANALYSIS						6.6	6.6	6.6		19.8
LAUNCH SUPPORT		1.4	6.2	18.4	14.7	5.7				46.4
TOTAL	5.4	17.1	26.0	43.4	30.8	18.6	6.6	6.6		154.5

Stratospheric Observatory for Infrared Astronomy

The initial development funding for the Stratospheric Observatory for Infrared Astronomy (SOFIA) was requested in the FY 1996 budget. This new airborne observatory will provide a significant increase in scientific capabilities over the Kuiper Airborne Observatory, which was retired in October, 1995. The SOFIA will be accommodated in a Boeing 747 and will feature a 2.5-meter infrared telescope to be provided by the German Space Agency (DARA). SOFIA will conduct scientific investigations at infrared and submillimeter wavelengths. The initial science flights for SOFIA are anticipated to occur in October 2001.

The budget estimates provided below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the costs of preliminary design studies carried out in previous years, the amounts being contributed by the international participants, or costs for the use of government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Suborbital program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	30.0	21.3	45.8	56.5	48.8	32.4				234.8
MISSION OPERATIONS							36.6	38.0	CONT.	CONT.
TOTAL EXCLUDING CIVIL SERVICE COSTS	30.0	21.3	45.8	56.5	48.8	32.4	36.6	38.0		
(ESTIMATED CIVIL SERVICE FTEs)	(7)	(38)	(40)	(40)	(41)	(40)	(41)	(41)		
C M L SERVICE COMPENSATION ESTIMATE ($M)	0.6	3.0	3.2	3.3	3.5	3.5	3.8	4.0		

Discovery Missions

Discovery missions are planetary exploration missions designed with focused science objectives that can be met with limited resources. Total development costs are not to exceed $150 million in constant FY 1992 dollars, and development schedules are limited to three years or less. Three Discovery missions have been launched: NEAR in February 1996, Mars Pathfinder in December 1996 and Lunar Prospector in January 1998. In addition, there is one approved Discovery mission currently in development: Stardust. In October 1997, NASA selected the next two Discovery missions: Genesis and the Comet Nucleus Tour (CONTOUR). The Genesis mission is designed to collect samples of the charged particles in the solar wind and return them to Earth laboratories for detailed analysis. It is scheduled to begin development in August 1998, to launch in January 2001, and to return its samples August 2003. CONTOUR's goals are to dramatically improve our knowledge of key characteristics of comet nuclei and to assess their diversity. Detailed design is expected to begin in October 1998, and the spacecraft is expected to launch in June 2002. It will leave Earth orbit, but stay relatively near Earth while intercepting at least three comets. Other future Discovery missions will be undertaken after selection through a peer review process.

The budgetary estimates provided below are the amounts included in the specific budget justification for this program within the Space Science section in the Science, Aeronautics and Technology appropriation. Under the specific mission descriptions, see below, other direct program cost elements are included: the development of the spacecraft and experiments, one year of mission operations, the launch services, and unique tracking and data acquisition services. They do not include costs for the use **of** government facilities and general and administrative support required to implement the program. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	*2000*	2001	2002	2003	BTC	TOTAL
NEAR	173.6	3.3	11.2	14.6	8.8					211.5
MARS PATHFINDER	245.9	11.8	4.6							262.3
LUNAR PROSPECTOR	36.4	20.6	4.3	2.2						63.5
STARDUST	30.6	63.7	56.2	25.8	3.5	3.7	3.7	5.0	17.8	210.0
GENESIS		0.8	37.6	63.8	65.8	25.3	6.5	7.2	7.2	214.2
FUTURE MISSIONS DEVELOPMENT		4.5	2.8	67.3	83.3	124.3	137.6	143.0	CONT	
FUTURE MISSIONS MO&DA						10.6	11.0	11.8	CONT	
FUTURE MISSIONS ELVs				7.2	21.4	40.6	48.2	59.2	CONT	
TOTAL EXCLUDING CML SERVICE COSTS ($M)	486.5	104.7	116.7	180.9	182.8	204.5	207.0	226.2		
(ESTIMATED CIVIL SERVICE FTEs)	(33)	(21)	(14)	(13)	(10)	(10)	(10)	(10)	Cont.	
CML SERVICE COMPENSATION ESTIMATE ($M)	2.3	1.6	1.1	1.1	0.9	0.9	0.9	1.0	Cont.	

Cassini

The Cassini mission will provide intensive, long term observations of Saturn's atmosphere, rings, magnetosphere and moons. The Huygens Probe will conduct direct physical and chemical analyses of the atmosphere of Saturn's moon, Titan. Cassini was approved as a new start by Congress in the FY 1990 budget. At the time it was initiated, a second spacecraft, the Comet Rendezvous and Asteroid Flyby (CRAF) was included. Congressionally-imposed reductions to FY 1992-93 funding requirements led to the termination of the CRAF mission and the deferral of the Cassini launch from April 1996 to October 1997. The Cassini program later underwent a significant redesign in early 1992 to reduce total program cost, mass and power requirements, while maintaining the October 1997 launch aboard a Titan IV launch vehicle. As a result of its successful launch on October 15, 1997, the spacecraft will arrive at Saturn in 2004 and begin a four year study of the Saturnian system. The program involves significant cooperation from international partners as well as U.S. government partners. The European Space Agency provided the Huygens Probe and the Italian Space Agency contributed the High Gain/Low Gain antenna for the spacecraft. There are twelve science instruments on the orbiter and six on the probe from international Principal Investigators. The Titan IV launch vehicle was procured from the Department of Defense, and the Radioisotope Heater Units (RHUs) and Radioisotope Thermoelectric Generators (RTGs) were procured by NASA from the Department of Energy.

The budgetary estimates provided below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts being contributed by the international participants, or for the use of government facilities and general and administrative support required to implement the program. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	*TOTAL,*
DEVELOPMENT	1301.3	74.6								1375.9
MISSION OPS & DATA ANALYSIS		15.0	38.1	55.8	55.0	53.6	60.8	70.7	396.0	745.0
LAUNCH SUPPORT	294.3	92.7	17.1							404.1
TRACKING & DATA SUPPORT	21.4	3.0	4.7	8.8	6.2	4.5	5.0	5.0	tbd	58.6
TOTAL EXCLUDING CML SERVICE COSTS ($M)	1617.0	185.3	59.9	64.6	61.2	58.1	65.8	75.7	396.0	2583.6
(ESTIMATED CML SERVICE FTEs)	(473)	(30)	(6)	(6)	(6)	(6)	(6)	(6)		
CML SERVICE COMPENSATION ESTIMATE ($M)	29.8	2.3	0.5	0.5	0.5	0.5	0.6	0.6		

Mars Pathfinder

The Mars Pathfinder was approved as a new start in FY 1994 as one of the initial missions in the Discovery Program. The Mars Pathfinder mission demonstrated a unique cruise, entry, descent, and landing system approach that will be available for future missions to Mars. The mission was conducted as an in-house effort at the Jet Propulsion Laboratory. Portions of the science instruments were provided by Germany and Denmark. Mars Pathfinder was launched in December 1996 on a Delta II expendable launch vehicle. Mars Pathfinder landed successfully on Mars on July 4, 1997, and returned a plethora of scientific data for three months (well past its design lifetime). The mission also captivated the media and the public: images were made available almost instantaneously over the World Wide Web, which recorded over 500 million hits from all over the globe by the end of July. The mission has provided evidence that liquid water once existed in large quantities on Mars' surface, and that the planet was more Earth-like during its early history than previously believed. Last contact with the spacecraft was made on October 7, 1997. The first scientific papers were published in December; analysis of the data is ongoing.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	174.2									174.2
MICROROVER	23.0	2.0								25.0
MISSION OPS & DATA ANALYSIS		9.6	4.4							14.0
LAUNCH SUPPORT	48.4									48.4
TRACKING & DATA SUPPORT	0.3	0.2	0.2							0.7
TOTAL	245.9	11.8	4.6							262.3

Near-Earth Asteroid Rendezvous (NEAR)

The NEAR was approved as a new start in FY 1994 as one of the initial Discovery Program missions. The NEAR mission was conducted as an in-house effort at the Applied Physics Laboratory, with many subcontracted subsystems. The NEAR spacecraft will conduct a comprehensive study of the near-Earth asteroid 433 EROS, including its physical and geological properties and its chemical and mineralogical composition. The NEAR spacecraft was launched February 17,1996 on a Delta II launch vehicle.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	124.9									124.9
MISSION OPS & DATA ANALYSIS	4.9	3.1	11.0	14.4	8.6					42.0
LAUNCH SUPPORT	43.5									43.5
TRACKING & DATA SUPPORT	0.3	0.2	0.2	0.2	0.2					1.1
TOTAL	173.6	3.3	11.2	14.6	8.8					211.5

Lunar Prospector

Lunar Prospector was selected as the third Discovery mission in FY 1995, and Phase C/D development started in the first quarter of FY 1996. The mission is designed to search for resources on the Moon, with special emphasis on the search for water in the shaded polar regions. Ames Research Center is managing the mission, and Lockheed Martin will provide the spacecraft, instruments, launch and operations. Launch on a Lockheed Launch Vehicle-I1 (LLV-II) occurred in January 1998. Launch costs are included in the development cost. Tracking and communications support will be provided by the Deep Space Network.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	36.4	19.8								56.2
MISSION OPS & DATA ANALYSIS		0.8	4.3	2.2						7.3
TOTAL	36.4	20.6	4.3	2.2						63.5

Stardust

The Stardust mission was selected as the fourth Discovery mission in November 1995, with mission management from the Jet Propulsion Laboratory. The mission team has completed the Phase B analysis, and Stardust was approved for implementation in October, 1996. The mission is designed to gather samples of dust from the comet Wild-2 and return the samples to Earth for detailed analysis. The mission will also gather and return samples of interstellar dust that the spacecraft encounters during its trip through the Solar System to fly by the comet. Stardust will use a new material called aerogel to capture the dust samples. In addition to the aerogel collectors, the spacecraft will carry three additional scientific instruments. An optical camera will return images of the comet: the Cometary and Interstellar Dust Analyzer (CIDA) is provided by Germany to perform basic compositional analysis of the samples while in flight: and a dust flux monitor will be used to sense particle impacts on the spacecraft. Stardust will be launched on the Med-Lite expendable launch vehicle in February 1999 with return of the samples to Earth in January 2006.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
PHASE A/B	9.6									9.6
DEVELOPMENT	13.5	52.2	42.3	9.8						117.8
MISSION OPS & DATA ANALYSIS				3.5	3.5	3.7	3.7	5	17.8	37.2
LAUNCH SUPPORT	7.5	11.5	13.9	12.5						45.4
TOTAL	30.6	63.7	56.2	25.8	3.5	3.7	3.7	5.0	17.8	210.0

Genesis

In October 1997 NASA selected Genesis as the fifth Discovery mission. The Genesis mission is designed to collect samples of the charged particles in the solar wind and return them to Earth laboratories for detailed analysis. It is led by Dr. Donald Burnett from the California Institute of Technology, Pasadena, CA JPL will provide the payload and project management, while the spacecraft will be provided by Lockheed Martin Astronautics of Denver, CO. Due for launch in January 2001, it will return the samples of isotopes of oxygen, nitrogen, the noble gases, and other elements to an airborne capture in the Utah desert in August 2003. Such data are crucial for improving theories about the origin of the Sun and the planets, which formed from the same primordial dust cloud.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
PHASE A/B		0.3	11.1							11.4
DEVELOPMENT			20.3	49.4	48.2	8.2				126.1
MISSION OPS & DATA ANALYSIS						10.2	6.0	6.7	7.2	30.1
LAUNCH SUPPORT		0.5	6.2	14.4	17.6	6.4				45.1
TRACKING & DATA SUPPORT						0.5	0.5	0.5		1.5
TOTAL		0.8	37.6	63.8	65.8	25.3	6.5	7.2	7.2	214.2

Mars Surveyor Program

The Mars Surveyor program is a series of small missions designed to resume the detailed exploration of Mars. The first mission in this program, the Mars Global Surveyor mission, was approved as a new start in FY 1994. The follow-on Mars Surveyor 98 Orbiter and Lander were approved in FY 1995. The Mars Surveyor '01 Orbiter and Lander are to enter development in FY 1998. Future small missions are targeted for launch in the launch windows that occur approximately every two years.

The budgetary estimates below are the amounts indicated in the budget justification within the Space Science section in the Science, Aeronautics and Technology appropriation. The specific write-ups for the Mars Global Surveyor and Mars 98 Orbiter/Lander missions include the amounts for the development of the spacecraft and instruments, two years of mission operations, and launch services. They do not include costs for the use of government facilities and general and administrative support used to carry out the program. **A** more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
MARS GLOBAL SURVEYOR	176.9	21.1	19.5	14.2	8.7	6.2	3.1			249.7
98 MARS ORBITER/LANDER	64.9	118.2	79.8	29.0	12.7	10.6	7.5			322.7
01 MARS ORBITER/LANDER			71.2	131.2	115.3	49.2	18.7			385.6
FUTURE MISSIONS	1.4	3.7	37.1	50.2	124.9	192.3	225.5	223.4	Cont.	858.5
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	243.2	143.0	207.6	224.6	261.6	258.3	254.8	223.4		1816.5
(ESTIMATED C M L SERVICE FTEs)	(43)	(19)	(27)	(24)	(25)	(23)	(30)	(30)	(Cont.)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	3.0	1.5	2.2	2.0	2.1	2.0	2.8	2.9	Cont.	

Mars Global Surveyor

This mission will obtain a majority of the expected science return from the lost Mars Observer mission by flying a science payload comprised of spare Mars Observer instruments aboard a small, industry-developed spacecraft. Launch occurred in November 1996 on a Delta II launch vehicle, and MGS entered Mars orbit in September 1997. The funding estimates provided below do not include the previous expenditures on spare Mars Observer instruments or the amount recovered from the prime contractor after the Mars Observer failure.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	130.7									130.7
MISSION OPS & DATA ANALYSIS		14.7	19.5	14.2	8.7	6.2	3.1			66.4
LAUNCH SUPPORT	46.2	6.4								52.6
TOTAL	176.9	21.1	19.5	14.2	8.7	6.2	3.1			249.7

98 Mars Orbiter/Lander

The 98 Mars Orbiter and Lander are the first follow-on missions in the Mars Surveyor program. The Orbiter **will** be launched on a Med-Lite launcher in December 1998, and the Lander will be launched on a Med-Lite in January 1999. Lockheed Martin Aerospace, Denver, was selected competitively to develop these spacecraft. The Orbiter will carry a color imager and a Pressure Modulater Infrared Radiometer (PMIRR),which was also a Mars Observer payload. The Lander will carry a descent imager, a comprehensive volatiles and climate payload, and a Russian LIDAR atmospheric instrument.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	52.4	86.3	41.1	13.3						193.1
MISSION OPS & DATA ANALYSIS				8.3	12.3	10.3	7.5		CONT.	38.4
LAUNCH SUPPORT	12.5	31.9	38.7	7.2						90.3
TRACKING & DATA SUPPORT				0.2	0.4	0.3				0.9
TOTAL	64.9	118.2	79.8	29.0	12.7	10.6	7.5			322.7

'01 Mars Orbiter/Lander

This mission will explore the ancient highlands of Mars to characterize the surface environment in terms of its geologic and aqueous history. The mission will collect data and demonstrate technologies critical to initiating the exploration of Mars by humans. The orbiter will carry the Thermal Emission Imaging System (THEMIS), while the rover on the Lander will carry the integrated suite of instruments. The Orbiter and the Lander will be launched on Delta 7425s in March 2001 and April 2001, respectively.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT			67.0	100.5	72.5	27.2				267.2
MISSION OPS & DATA ANALYSIS						6.6	18.7		CONT.	25.3
LAUNCH SUPPORT			4.2	30.7	42.8	15.4				93.1
TRACKING & DATA SUPPORT										
TOTAL			71.2	131.2	115.3	49.2	18.7			385.6

Future Surveyor Missions

The Mars Surveyor landers planned in future years -- 2003, 2005 and beyond -- will capitalize on the experience of the Mars Pathfinder lander mission launched in November 1996. The small orbiter to be launched in 2003 will draw on the experience of Mars Global Surveyor and carry other scientific instruments into orbit to complete Mars Global Surveyor's science missions. A Mars sample return mission is being considered for the FY 2005 opportunity.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	1.4	3.7	37.1	50.2	116.3	165.3	175.8	189.8		739.6
MISSION OPS & DATA ANALYSIS									CONT.	
LAUNCH SUPPORT					8.6	27.0	49.7	**33.6**	cont.	118.9
TRACKING & DATA SUPPORT										
TOTAL	1.4	3.7	37.1	50.2	124.9	192.3	225.5	223.4		858.5

Space Science New Millennium Spacecraft

The New Millennium program is an advanced development effort started in FY 1996 to demonstrate how complex scientific spacecraft--such as those required for planetary missions--can be built for lower mission costs and have short development times, while still possessing considerable scientific merit. The New Millennium Spacecraft program will enable the introduction of the latest technology advances into spacecraft for planetary and outer solar system explorations. The primary objectives of the program are to increase the performance capabilities of spacecraft and instruments while simultaneously reducing total costs of future science missions, thereby allowing more frequent flight opportunities even under the severe budget constraints of the future. In previous years, NASA and the Department of Defense have funded technology developments which offer extraordinary promise. This precursor work on technologies can now be demonstrated in a series of flight technology demonstration missions occurring at a rate of one every 1.5 years, with the initial flight planned for the mid-1998 time frame.

The budgetary estimates below represent funding included in the Science, Aeronautics and Technology appropriation. The program is designed as an ongoing program, and funding is included for development and launch of one mission per every one and one half years, beginning in 1998. Launches are generally targeted for small expendable launch vehicles. The budget estimate below does not include the costs for the government facilities and general and administrative support used to carry out the research and development activities. Additional information on the first two missions is provided later in this section. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEEP SPACE 1	41.2	40.1	51.8	4.3	2.6					140.0
DEEP SPACE 2	8.6	8.9	6.5	1.7	0.8					26.5
FUTURE MISSIONS INCLUDING PROGRAM COSTS	20.9	11.3	17.1	65.1	62.0	67.1	78.5	99.9		421.9
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	70.7	60.3	75.4	71.1	65.4	67.1	78.5	99.9		421.9
(ESTIMATED CIVIL SERVICE FTEs)	(2)	(319)	(283)	(288)	(301)	(309)	(312)	(312)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	0.1	24.8	22.7	23.9	25.9	27.4	28.9	30.4		

Deep Space 1

Deep Space 1 was selected in FY 1996 as the first New Millennium Program mission. The technology to be validated will include solar electric propulsion, an advanced solar array, autonomous primary navigation, and miniature imaging camera spectrometer. Spectrum Astro was selected in FY 1996 to integrate the spacecraft. DS 1 is expected to launch in July, 1998 on a Med-Lite-class Delta launch vehicle. The supplemental technology development line below contains funding for crosscutting technology development efforts previously managed by the Office of Space Access and Technology.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	26.3	28.9	18.1							73.3
SUPPLEMENTAL TECH DEV	7.2	6.1	1.6							14.9
MISSION OPS & DATA ANALYSIS				4.2	2.6					6.8
LAUNCH SUPPORT	7.7	5.0	31.9							44.6
TRACKING & DATA SUPPORT		0.1	0.2	0.1						0.4
TOTAL	41.2	40.1	51.8	4.3	2.6					140.0

Deer, Space 2

Deep Space 2 was selected in FY 1996 as the second of the series of missions under the New Millennium Program. DS 2 is designed to develop and validate technologies and systems required to deliver multiple small packages to the surface and/or subsurface of Mars using direct entry. Some of the technologies to be validated include a microtelecommunications system, power electronics, a microcontroller, flexible interconnects for system cabling, a meteorological, high-g pressure sensor, and a sample/ water experiment. DS 2 will be attached to (“piggyback”on) the Mars 98 Lander, which is scheduled to launch in January 1999.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	BTC	TOTAL
DEVELOPMENT	6.8	8.4	3.5	1.3	0.4					20.4
SUPPLEMENTAL TECH DEV	1.8	0.5	1.0							3.3
MISSION OPS & DATA ANALYSIS			0.4	0.4	0.4					1.2
ELV INTEGRATION			1.6							1.6
LAUNCH SUPPORT										
TRACKING & DATA SUPPORT										
TOTAL	8.6	8.9	6.5	1.7	0.8					26.5

Earth Observing System

Before the Earth Observing System (EOS) was authorized in November 1990 in the FY 1991 budget as a new start, EOS planning had been in progress for over eight years. The EOS is key to achieving the objectives set forth in the Earth Science program plan and the overall goal and scientific objectives of the interagency U.S. Global Change Research Program. EOS is an international science program, drawing upon the contributions of Europe (ESA), Canada, and Japan both in terms of spacecraft and instruments. This extraordinary collaboration is essential to reach the objective of providing long-term (15 years), comprehensive measurements of the nature of global climate change.

At its outset, the EOS program was based on the flights of two series of large platforms, in addition to platforms from Japan and ESA and instruments carried on Space Station Freedom. Although EOS was understood to be a program having a 15-year period of flight operations, the initial estimates provided to Congress focused on the period through fiscal year 2000. The initial estimate of $18-21 billion included development, mission operations, data analysis, launch services, communications, construction of facilities and the amounts carried in the Space Station program for the polar platform's development. In the FY 1992 appropriations process, Congress directed NASA to modify the scope and cost of the program. The cost through FY 2000 was to be reduced by $5 billion, the FY 1993 funding level had to be reduced, and NASA was to examine the feasibility of using smaller platforms. In 1991, the program was restructured to employ five smaller flight series. In 1992, in response to the constrained budget environment, NASA further rescoped the program by implementing a common spacecraft approach for all flights after the first morning series (AM-1) spacecraft, increasing reliance on the cooperative efforts of international and other government agencies, and adopting a build-to-cost approach for the first unit of a multiple instrument build. The estimated NASA funding through FY 2000 was further reduced to $8.0 billion in this effort.

In the FY 1995 budget process, the program cost estimate was further adjusted downward by approximately $0.9 billion, of which $0.3 billion reflected an accounting transfer for small business innovative research out of individual programs into a common NASA account, and $0.1 billion reflected the change to lower-cost launch vehicles. The further reductions in program funding were addressed in 1994 through a program rebaselining activity. A number of small spacecraft were introduced into the program flight plans. In addition, alterations were made in flight phasing and accommodations were provided for a follow-on instrument to the enhanced thematic mapper being flown in 1998 on Landsat-7. Funding for the science investigations and data analysis was separated from the algorithms being developed to convert the instrument data into information. This change recognized the close relationship to similar science investigations and data analysis funded in the Earth Science research and analysis account. (The amounts budgeted for EOS science are shown in the table below.) In addition, it was decided to incorporate the development funding for the Landsat-7 into the EOS program in light of the integral ties between the two activities.

In the FY 1996 budget process, the amounts reflected the related program costs for Landsat-7 activities previously funded by the Department of Defense.

The 1997 Biennial Review completed the shift in planning for future missions (i.e., beyond the EOS first series) that began in the 1995 "reshaping" exercise. Emerging science questions drive measurement requirements, which drive technology investments in advance of instrument selection and mission design. Mission design includes such options as purchase of science data from commercial systems and partnerships with other Federal agencies and international agencies. The result is a more flexible and less expensive, approach to acquiring Earth science data.

The budgetary estimates below represent funding included in the Science, Aeronautics and Technology appropriation. The amounts below reflect the effects of the rescoping of the EOS program, the impacts of the ZBR, and the inclusion of the estimate for FY 2002. They do not include the costs of the non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Earth Science section.

(Budget Authority in Millions of Dollars)

Earth Observing System	**Prior**	**1997**	**1998**	**1999**	**2000**	**Subtotal Through FY 2000**	**2001**	**2002**	**2003**	**Total Through FY 2003**
MORNING SERIES	1,022.6	82.8	44.9	6.1	2.9	1,159.3				1,159.3
AFTERNOON SERIES	306.9	147.5	175.9	124.2	124.4	878.9	27.9			906.8
CHEMISTRY	49.1	46.6	100.6	140.9	127.1	464.3	105.4	64.2	26.6	660.5
SPECIAL SPACECRAFT	203.1	65.5	101.2	152.1	178.8	700.7	141.3	112.4	92.4	1,046.8
QUIKSCAT		35.0	34.5	7.9	2.5	79.9	0.6			80.5
LANDSAT 7	269.2	78.8	52.6	2.0	1.5	404.1				404.1
EOS FOLLOW-ON			5.5	24.8	53.7	84.0	181.7	237.2	287.9	790.8
ALGORITHM DEVELOPMENT	268.0	75.9	96.3	122.9	135.0	698.1	131.0	132.2	134.1	1,095.4
TECHNOLOGY INFUSION	26.5	50.1	93.1	78.2	76.6	324.5	89.3	107.9	97.2	618.9
EOSDIS	900.4	234.6	209.9	256.6	247.9	1,849.4	245.6	233.6	262.9	2,591.5
SUBTOTAL	3,045.8	816.8	914.5	915.7	950.4	6,643.2	922.8	887.5	901.1	9,354.6
PHASE B	41.0					41.0				41.0
SPACE STATION PLATFORM	104.0					104.0				104.0
EOS SCIENCE	93.8	37.5	37.4	40.9	76.0	285.6	68.4	68.3	65.6	487.9
LAUNCH SERVICES	153.9	84.7	34.8			273.4				273.4
CONSTRUCTION OF FACILITIES	96.7					96.7				96.7
TOTAL EXCLUDING CML SERVICE COSTS ($M)	3,535.2	939.0	986.7	956.6	1,026.4	7,443.9	991.2	955.8	966.7	10,357.6
(ESTIMATED CIVIL SERVICE FTEs)	(2,601)	(524)	(589)	(554)	(559)		(562)	(552)	(552)	
CML SERVICE COMPENSATION ESTIMATE ($M	172.4	40.8	47.1	45.9	48.1		49.8	51.2	53.8	

EOS New Millennium Program and Technology Infusion

The New Millennium Program (NMP) and Technology Infusion budget reflects a commitment to develop new technology to meet the scientific needs of the next few decades and to reduce future EOS costs. The program objectives are to spawn "leap ahead" technology by applying the best capabilities available from several sources within the government, private industries and universities, The first mission EO- 1, has been selected to demonstrate innovative technology to produce Landsat data. The Space-Readiness Coherent Lidar Experiment (Sparcle) was officially selected as an EO-2 mission in November 1997.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	TOTAL
EO- 1	15.5	33.0	29.0	9.0					86.5
EO-2 SPARCLE			7.7	4.7	1.9	0.7			15.0
NMP TECHNOLOGY & FUTURE FLIGHTS	5.5	6.7	0.4	29.5	42.9	52.6	65.0	60.0	262.6
LAUNCH SERVICES			28.2	9.5	6.3	10.5	17.4	9.7	81.6
SENSOR & DETECTOR TECHNOLOGY	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	44.0
INSTRUMENT INCUBATOR		4.9	22.3	20.0	20.0	20.0	20.0	22.0	129.2
TOTAL EXCLUDING CML SERVICE COSTS ($M)	26.5	50.1	93.1	78.2	76.6	89.3	107.9	97.2	618.9
(ESTIMATED CIVIL SERVICE FTEs)	(1)	(67)	(82)	(36)	(14)	(10)	(7)	(7)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M	0.1	5.2	6.6	3.0	1.2	0.9	0.6	0.7	

Earth Probes

The Earth Probes program consists of spacecraft and instrument developments to address specific, highly-focused mission requirements in Earth science research. They are complementary to the scientific data-gathering activities carried out within the EOS program, The currently approved Earth probes are the Total Ozone Mapping Spectrometer (TOMS),and the Tropical Rainfall Measuring Mission. The Earth System Science Pathfinder missions will be funded to take advantage of the new technologies in spacecraft and instrument design being developed by other federal agencies and by NASA. The Experiments of Opportunity funding will accommodate opportunities to provide flight instruments and technologies on non-Earth Science missions, foreign or domestic, or on airborne experiments. The Lewis and Clark missions were transferred from the Office of Space Access and Technology when that office was dissolved.

The budgetary estimates below represent funding included in the Science, Aeronautics and Technology appropriation. The program is designed as an ongoing program, The budget estimates immediately below do not include the estimated costs incurred by the international collaborators, mission operations, science costs, launch services, related funding included in the Earth Observing System program, NASA civil service work force salary and expenses, use of government facilities and general and administrative support used to carry out the research and development activities. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Earth Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	TOTAL
TOTAL OZONE MAPPING SPECTROMETER	107.5	3.9	8.2	4.9	4.9	0.4			129.8
TROPICAL RAINFALL MEASURING MISSION	227.8	17.3	0.9						246.0
LEWIS & CLARK	117.0	12.0	3.0	5.0					137.0
EARTH SYSTEM SCIENCE PATHFINDERS	1.0	14.0	33.9	70.0	85.4	106.1	121.1	98.5	Continues
EXPERIMENTS OF OPPORTUNITY		2.6	2.6	1.0	3.0	3.0	3.0	3.0	Continues
(ESTIMATED CIVIL SERVICE FTEs)	(756)	(138)	(77)	(54)	(56)	(55)	(53)	(53)	
CML SERVICE COMPENSATION ESTIMATE ($M	49.9	10.7	6.2	4.5	4.8	4.9	4.9	5.2	

Total Ozone Mapping Spectrometer

The TOMS Earth Probes program is a follow-on to the Total Ozone Mapping Spectrometer (TOMS)instrument flown with such great success on the Nimbus-7 spacecraft in 1978. A TOMS instrument was also flown on the Russian METEOR spacecraft in 1991. The TOMS program consists of a set of instruments (flight models 3, 4, 5) and one small spacecraft. Flight model **3** was launched on the TOMS Earth probe spacecraft on July 2, 1996. Flight model 4 was launched on the Japanese ADEOS spacecraft on August 17, 1996. The ADEOS-I spacecraft failed on June 30, 1997. Flight model 5 is currently planned for a cooperative mission with the Russian Space Agency in the year 2000.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	TOTAL
DEVELOPMENT	107.5	3.9	8.2	4.9	4.9	0.4			129.8
MISSION OPERATIONS		5.5	5.7	5.1	5.0	4.0	3.5	3.5	32.3
SCIENCE TEAMS		0.9	0.9	0.9	1.0	1.1	1.1	1.0	6.9
SELV	16.7								16.7
TOTAL EXCLUDING CML SERVICE COSTS ($M)	124.2	10.3	14.8	10.9	10.9	5.5	4.6	4.5	185.7
(ESTIMATED CIVIL SERVICE FTEs)	(138)	(7)	(7)	(7)	(6)	(1)			
CIVIL SERVICE COMPENSATION ESTIMATE ($M	9.0	0.5	0.6	0.6	0.5	0.1			

Tropical Rainfall Measuring Mission

The Tropical Rainfall Measuring Mission (TRMM) was launched aboard the Japanese H-II vehicle November 27, 1997. The TRMM development began in FY 1992, after a four-year period of concept studies and preliminary mission definition. The TRMM objective is to obtain a minimum of three years of climatologically significant observations of tropical rainfall. TRMM data will be useful to understand the ocean-atmosphere coupling, especially in the development of El Niño events, which form in the tropics but whose effects are felt globally. The observatory spacecraft was built in-house at the Goddard Space Flight Center. The Japanese built a critical instrument, the Precipitation Radar. Two other instruments are being developed with TRMM program funding, the Visible and Infrared Scanner and TRMM Microwave Imager. In 1992, two EOS-funded instruments were added to the payload, the Clouds and Earth's Radiant Energy System (CERES) and the Lightning Imaging Sensor (LIS). The budget estimates provided below include the costs of accommodating these two instruments on the TRMM observatory. The EOS Data and Information System will have a specific capability for disseminating TRMM data.

(Budget Authority in Millions of Dollars)

	PRIOR	1997	1998	1999	2000	2001	2002	2003	TOTAL
DEVELOPMENT	227.8	17.3	0.9						246.0
EOS-FUNDED INSTRUMENTS/SCIENCE/DIS	[39.9]	[10.3]	[8.8]	[12.6]					[71.6]
MISSION OPERATIONS		0.8	11.3	10.9	11.0	9.7	5.6	3.4	52.7
SCIENCE TEAMS		2.1	11.2	16.3	14.4	14.9	4.6		63.5
RESEARCH & ANALYSIS-FUNDED SCIENCE	29.5	5.9							35.4
TOTAL, EXCLUDING CML SERVICE COSTS ($M)	257.3	26.1	23.4	27.2	25.4	24.6	10.2	3.4	397.6
(ESTIMATED CIVIL SERVICE FTEs)	(594)	(101)	(30)	(1)	(1)	(1)	(1)	(1)	
CML SERVICE COMPENSATION ESTIMATE ($M	39.6	7.9	2.4	0.1	0.1	0.1	0.1	0.1	

Fiscal Year 1999 Budget Estimates

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